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Measuring Buffer Capacity

Buffer capacity (β) is a measure of the amount of acid or base that can be added to a solution without changing the pH of the solution by more than 1 pH value divided by the pH.

$$\beta = \frac{mol\ of\ acid/base\ neutralized}{pH\ of\ buffer\ solution}$$

Buffer capacity is determined experimentally using a titration procedure which measures the pH of a solution as acid or base is added in small increments.

In this lab, the buffer capacity of a particular buffer solution will be determined.

Choose one of the following scenarios and create a buffer solution to meet the requirements. Then test the buffer capacity using the following procedure.

Scenario 1: Prepare a buffer for an antibiological agent which is designed for use in the human body. This buffer should have a pH of 7.2 ± 0.5 with the ability to stay within one pH unit of this target when strong acid or base is added.

Scenario 2: Prepare a buffer for an antifungal agent which is designed for use against a fungus that attacks food sources that grow in *acidic* soil. This buffer should have a pH of 4.7 ± 0.5 with the ability to stay within one pH unit of this target when strong acid or base is added.

Scenario 3: Prepare a buffer for an antifungal agent which is designed for use against a fungus that attacks food sources in *basic* soil. This buffer should have a pH of 9.2 ± 0.5 with the ability to stay within one pH unit of this target when strong acid or base is added.

Scenario 4: Prepare a buffer for an antiviral agent which is designed for use against a strain of virus that attacks drug-producing bacteria that survive and grow in acidic environments. This buffer should have a pH of 3.1 ± 0.5 with the ability to stay within one pH unit of this target when strong acid or base is added.

✔**CHECKPOINT:** Check your buffer recipe with your teacher before you proceed to the procedure below.

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Procedure

1. Prepare 100 mL of buffer solution using the amounts of solution and salt determined appropriate for your desired pH.
2. Label a 250-mL beaker “ACID” and measure 50 mL of your buffer solution into this beaker.
3. Label a second 250-mL beaker “BASE” and measure 50 mL of your buffer solution into that beaker. Set the BASE beaker aside to use later.
4. Use the pH meter’s electrode (or probe) to measure the pH in the ACID beaker. Record this initial pH in the data table.
5. To complete the titration, 0.20 *M* hydrochloric acid (HCl) will be added to the buffer solution in varying increments using a buret. (The purpose of varying the amount of acid added is to create a smooth curve by adding smaller amounts when the pH changes noticeably.)
    a. Add the first indicated amount of 0.20 *M* HCl to the buffer solution.
    b. Record the *precise* volume added by reading the buret’s measurement. (The volume measurements may be exactly on the line, in which case –.00 should be recorded; however it is ok if the meniscus ends up slightly above or below the line, in which case you should record a proper estimated value.)
    c. Stir the solution thoroughly and allow the pH probe to stabilize, then record the pH data.
    d. Repeat the procedure for all the amounts of HCl listed below until you reach a total of 50.00 mL added. (**Check off each box as you go to keep track.)

Increment amount	Total amount added
☐ 5.00 mL	☐ 5.00 mL
☐ 5.00 mL	☐ 10.00 mL
☐ 2.00 mL	☐ 12.00 mL
☐ 2.00 mL	☐ 14.00 mL
☐ 2.00 mL	☐ 16.00 mL
☐ 1.00 mL	☐ 17.00 mL
☐ 1.00 mL	☐ 18.00 mL
… continue adding 1.00 mL increments until you reach 30.00 total mL added.	…
	☐ 30.00 mL
☐ 2.00 mL	☐ 32.00 mL
… continue adding 2.00 mL increments until you reach 40.00 total mL added	…
	☐ 40.00 mL
☐ 5.00 mL	☐ 45.00 mL
☐ 5.00 mL	☐ 50.00 mL

6. Flush the resulting mixture (buffer and HCl) down the sink with copious amounts of water. Rinse the beaker well and set out to dry. Rinse the pH probe well with distilled water.
7. Use the pH meter’s rinsed probe to measure the pH in the BASE beaker. Record this initial pH in the data table. (This value should be the same as your initial pH for the acid titration.)
8. Repeat the titration procedure described in Step 5 using 0.20 *M* sodium hydroxide (NaOH).
9. When finished, flush the resulting mixture (buffer and NaOH) down the sink with copious amounts of water. Rinse the beaker well and set out to dry. Rinse the pH probe and replace in the storage bottle with pH buffer solution.

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Titration with HCl			Titration with NaOH		
Total volume HCl added (mL)	**Total amount HCl added (mol)**	**pH**	**Total volume NaOH added (mL)**	**Total amount NaOH added (mol)**	**pH**
0	0		0	0	
5			5		
10			10		
12			12		
14			14		
16			16		
17			17		
18			18		
19			19		
20			20		
21			21		
22			22		
23			23		
24			24		
25			25		
26			26		
27			27		
28			28		
29			29		
30			30		
32			32		
34			34		
36			36		
38			38		
40			40		
45			45		
50			50		

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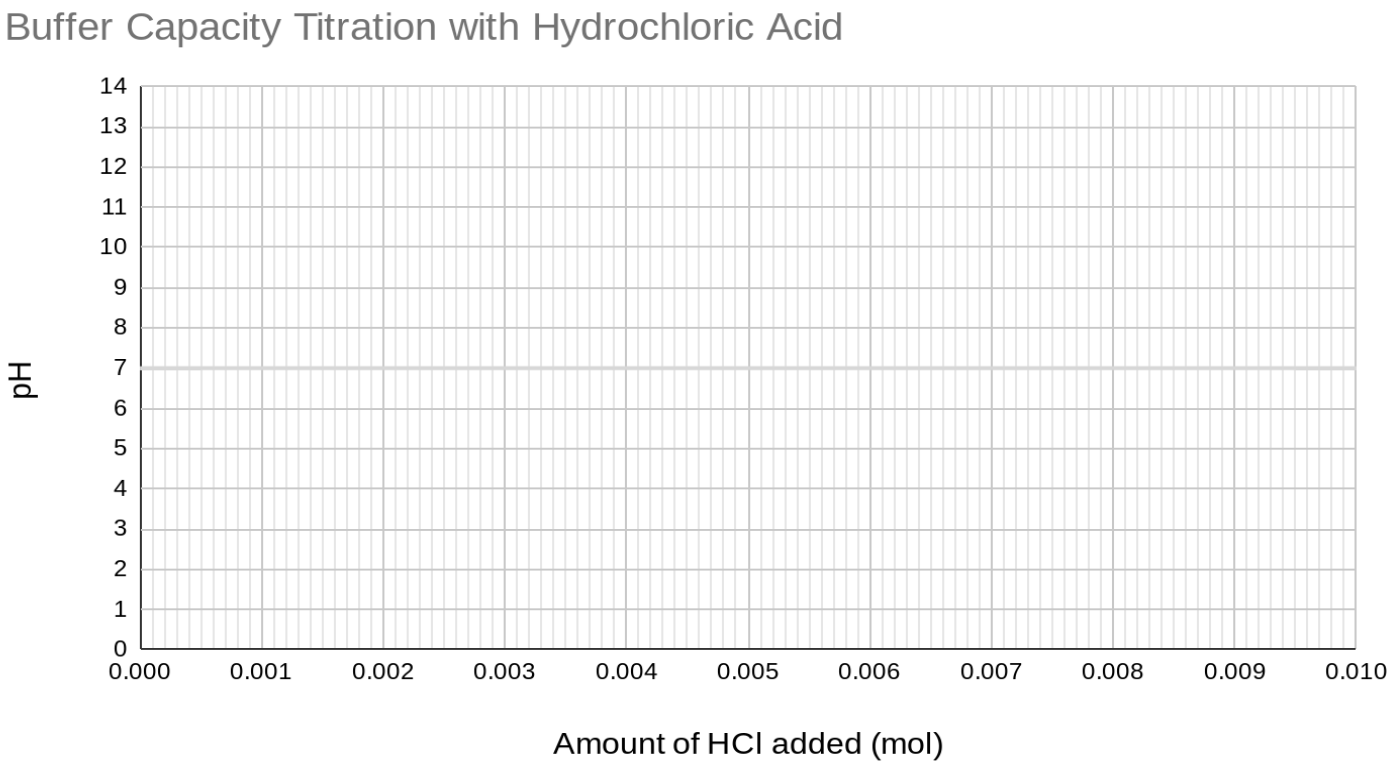
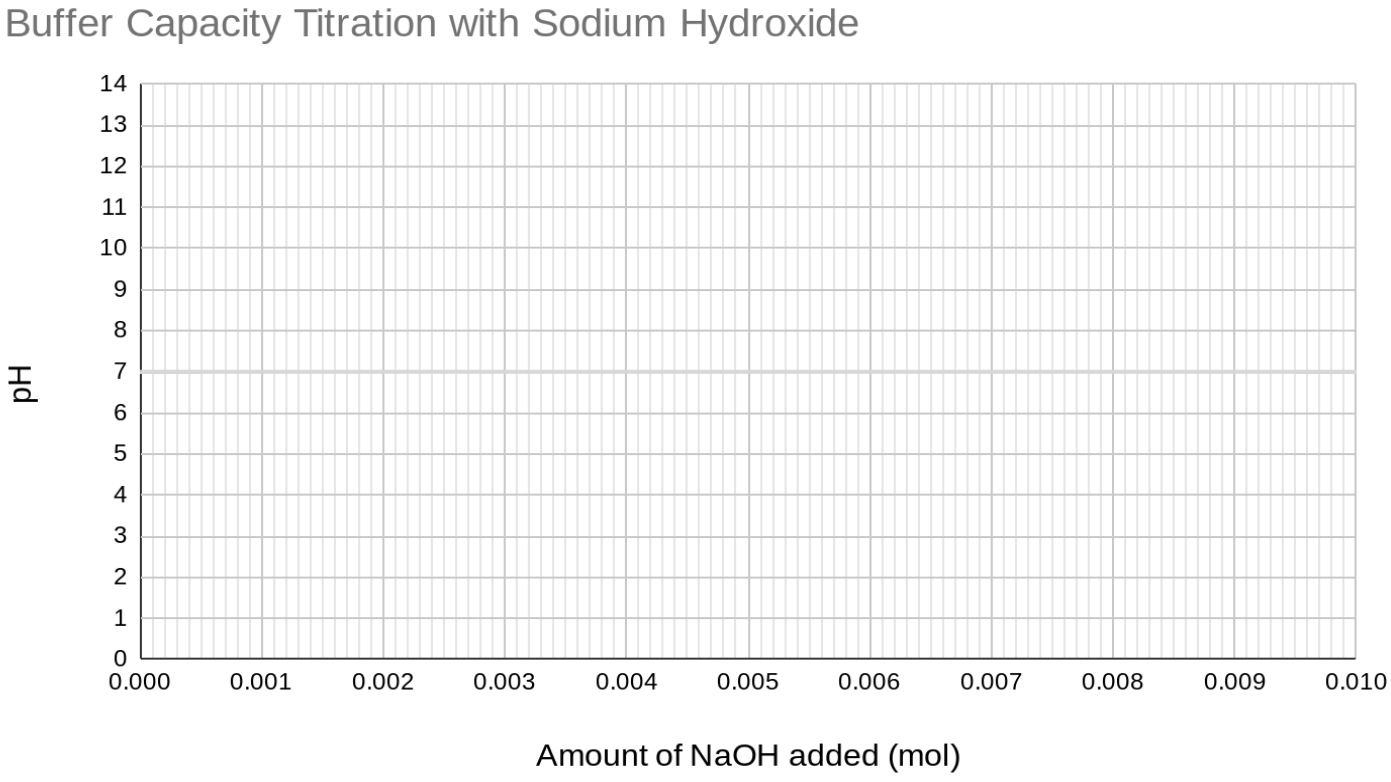
Analysis

Graph the pH vs. Total amount added (mol) for both HCl and NaOH.





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1. Determine how many moles of acid and base were neutralized by finding the data point that is approximately 1 pH value removed from the initial pH.

   Moles of HCl neutralized = _____ mol

   Moles of NaOH neutralized = _____ mol

2. If the theory that the acids added to a buffer solution are neutralized by the conjugate base component of a buffer and the bases added are neutralized by the conjugate acid. What ratio would you expect to exist between the moles of acid/base neutralized and the moles of the conjugate present in the solution?

   a. Verify the theory that acids added to a buffer solution are neutralized by the conjugate base component of the buffer by comparing the amount in moles of HCl neutralized (from question 2) to the amount in moles of conjugate base (CB) in the buffer solution.

   Ratio = ____ mol HCl : ____ mol CB

   b. Then verify the theory by comparing the moles of NaOH neutralized to the amount of conjugate acid (CA) in the solution.

   Ratio = ____ mol NaOH : ____ mol CA

3. Calculate the buffering capacity for both HCl and NaOH using the equation:

$$\beta = \frac{mol\ of\ acid/base\ neutralized}{pH\ of\ buffer\ solution}$$