CHM 116 LAB PROCEDURE
Preparation of Buffer Solutions

(~1 – 2 hours)

Introduction:

In this experiment, you will create buffer solutions using **acetic acid** and **sodium acetate**. Recall that a buffer is an aqueous solution consisting of a mixture of a **weak acid** and its **conjugate base**, or vice-versa.

In ***Experiment 1***, you will create five buffers containing various ratios of these two solutions and measure how these ratios affect overall pH using a pH meter. You will also calculate the predicted pH values of these five buffers using the concentrations of the acetic acid and sodium acetates along with the Henderson-Hasselbalch equation:

$$pH = pK_a + log\frac{[base]}{[acid]}$$

In ***Experiment 2***, you will evaluate the buffering capacity of your acetic acid/sodium acetate buffer as compared to distilled water. First an acidic substance (cola, containing phosphoric and carbonic acids) will be added to the buffer and to water to investigate these solutions' resistance to pH change. Then a basic substance (borax) will be added to the buffer and to water to again observe the relative resistance to pH change.

Materials List:

Amount	Material
50 mL	4.5% acetic acid, CH_3COOH
4 g	sodium acetate, CH_3COONa
4 g	Borax, $Na_2B_4O_7$
25 mL	*Coca-Cola (or any cola, regular not diet)
1 set	6.86 and 4.01 pH calibration powders
1	pH meter
2	250 mL Erlenmeyer flasks ***Note: See below***
6-7	pipettes
6	100 mL beaker
1	10 mL graduated cylinder
1	100 mL graduated cylinder
1	scale
2	weigh boat
1	metal spatula
1	stir rod
--	*Paper towels
1	*Camera/smart phone
1	*Permanent marker
>650 mL	*Distilled water **You may want to have EXTRA distilled water for this experiment since you have to rinse your pH meter often.**

*You Must Provide.

Note: *The 250 mL plastic Erlenmeyer flasks were chosen for containing the pH calibration solutions simply because they are the correct size to hold the solution and the mouths of the flasks are large enough to insert the pH meter. If your kit contained the substituted glass 250 mL Erlenmeyer flasks, your pH meter will not fit through the smaller mouth of these flasks. If this is the case for you, you will need to mix up your calibration solutions in containers from your home. Any clean glass or plastic container (such as a drinking glass, measuring cup, or Mason jar) that is large enough to hold more than 250 mL of solution and has an opening that your pH meter will fit through will work for this purpose, and you will need two. Just make sure that the containers are well cleaned both before and after their use for this experiment.*

Procedure:

Take a picture of yourself (head-to-toe) in your PPE (long sleeves shirt, safety glasses, and gloves) and correct lab attire (long pants, closed-toed shoes, long hair pulled back and NO jewelry) with the **can or bottle of cola to date your photo.*

You must wear the appropriate attire and PPE for the duration of the lab!

***It is recommended that you take pictures of your results during the experiment for reference in completing your Post-Lab.*

Before you begin:

- Read the SDS for 4.5% acetic acid (CH_3COOH), sodium acetate (CH_3COONa), and borax ($Na_2B_4O_7$).
- Put on proper PPE. Take **ONE** picture of yourself wearing your PPE and holding the **can or bottle of cola.**
- Set out all of the Materials needed for this experiment on an underpad provided in the Safety Box.

  Note: *There are not enough underpads to have one for each experiment. You may re-use the underpads.*

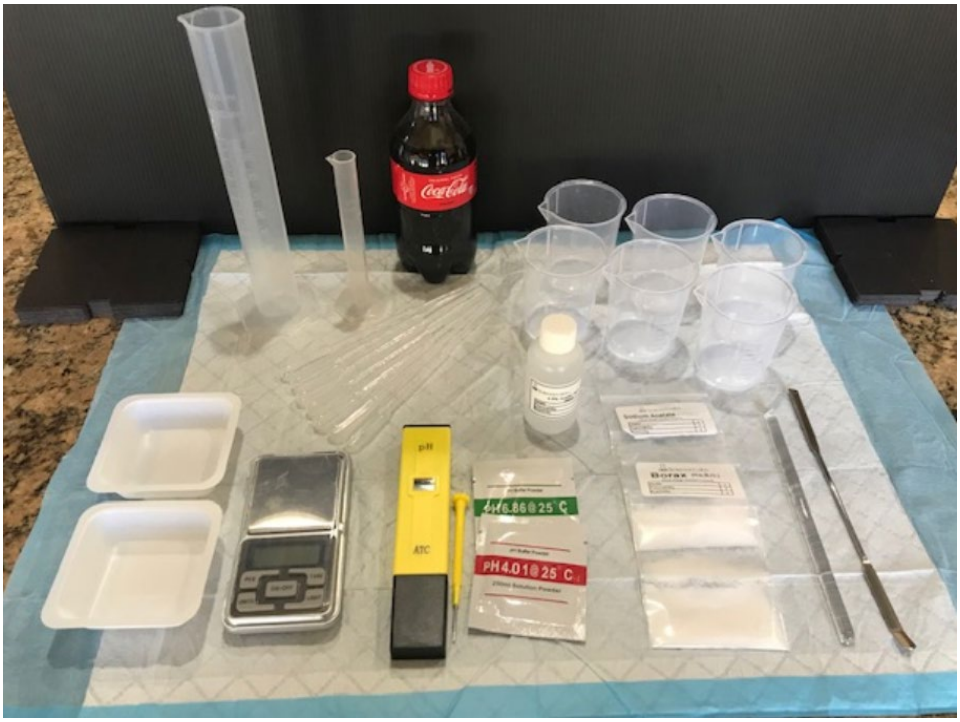

Figure 1. Materials needed for Preparation of Buffer Solutions Lab.

READ BOTH EXPERIMENTS IN THE PROCEDURE BELOW BEFORE STARTING YOUR LAB.

Part 1—Calibration of pH Meter

Before you begin:

Please calibrate your pH meter according to the instructions provided.

Note: **If you do not properly calibrate the meter prior to using, your results will be flawed.**

NOTE: DO NOT discard the calibration solutions after your initial calibration. You will be using the pH meter several times during the course of this experiment. Between Experiment 1 and Experiment 2 you will be directed to recalibrate your pH meter to ensure accurate readings.

Part 2 - Preparation of Sodium Acetate Solution

1. Weigh out approximately **4 g of sodium acetate** into the weigh boat using the metal spatula. **Record the exact mass (to one place past the decimal) of the sodium acetate in Table 1.**

   Note: *To use the scale, turn on the by pressing the button labeled ON/OFF (or the 0/T button if your scale does not have an on/off button) If your scale does not turn on, you may have to remove the battery cover and remove a small strip of plastic from the battery housing OR you may have to replace the batteries. Once the scale is on, press the TARE (or 0/T) button to zero the scale. Make sure that the units are in grams (g). If not, press the UNITS (or M) button until the units are displayed in grams. Once the scale is zeroed and displaying the correct units, place the weigh boat on the scale and zero the mass the of the weigh boat by pressing the TARE (or 0/T) button.* ***See Figure 4.***

Figure 4*. Scale zeroed with the weigh boat (left) and with 4.0 g* ***CH_3COOH*** *(right)*

Table 1. Sodium Acetate Solution Data

Mass of Sodium Acetate (g)	Volume of Sodium Acetate (mL)	Concentration of Sodium Acetate Solution (M)

2. Transfer the 4 g of **sodium acetate** to a 100 mL beaker labeled **"CH_3COONa"**.

3. Use the 100 mL graduated cylinder to measure and pour approximately 100 mL of distilled water into the beaker to dissolve the sodium acetate. **Record the exact volume (to one decimal place) in Table 1.**

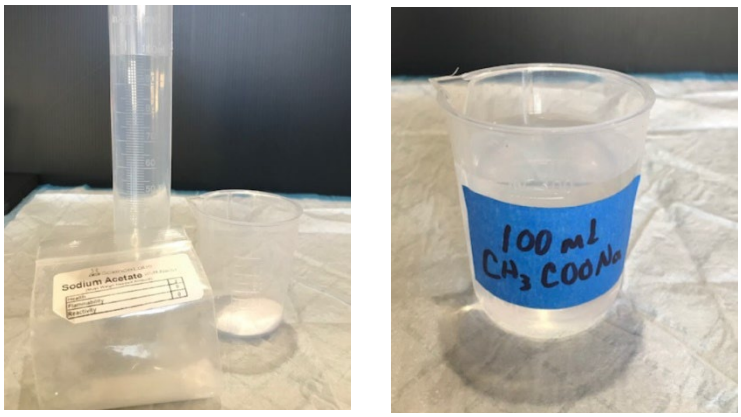

Figure 5. *4.0 g* ***CH_3COONa*** *and 100 mL H_2O before mixing (left) and 100 mL* ***CH_3COONa*** *solution after mixing (right).*

4. Gently stir the solution with a stir rod until a homogeneous solution forms. **See Figure 5**.
   Be careful not to stir too vigorously as it could cause a spill which will affect the concentration.

5. Calculate the **molarity** of the sodium acetate solution and label the beaker with the correct concentration and name of this solution. **Record the concentration (in molarity) in Table 1.**
   Note: *The molar mass of sodium acetate is 82.0343 g/mol.*

Part 3 - Preparation and pH Measurement of CH_3COOH/ CH_3COONa Buffer Solutions

1. Use a permanent marker to label 5 clean 100 mL beakers as **A, B, C, D and E**. **See Figure 6**.

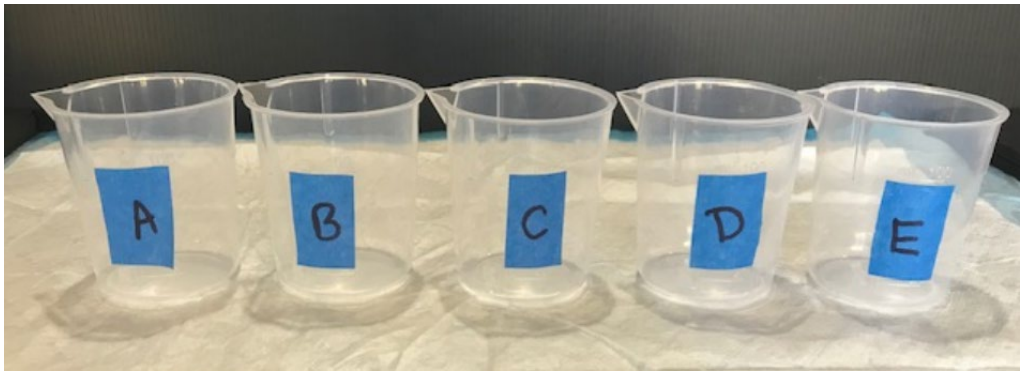

Figure 6. *Clean 100 mL beakers labeled A, B, C, D, and E.*

2. Label a clean pipette "***CH_3COOH"*** and use this pipette to transfer **4.5% acetic acid** into the clean 10 mL graduated cylinder in the amounts indicated in Table 2 below and pour in to the appropriate labeled 100 mL beakers (use the pipette to measure and deliver the 1 mL amounts to the beakers).

3. Wash and dry the 10 mL graduated cylinder.

4. Label a clean pipette "***CH_3COONa"*** and use this pipette to transfer the prepared **sodium acetate** into the clean 10 mL graduated cylinder in the amounts indicated in Table 2 below and pour in to the appropriate labeled 100 mL beakers (use the pipette to measure and deliver the 1 mL amounts to the beakers).

Figure 7. ***Acetic acid*** *and* ***sodium acetate*** *solutions in preparation to mix Buffers A, B, C, D, and E.*

Table 2. Measured pH Values and Predicted (Calculated) pH Values for CH_3COOH/ CH_3COONa Buffers

Buffer	Volume of Acetic Acid (mL)	Volume of Sodium Acetate (mL)	Measured pH	[CH_3COOH]	[CH_3COONa]	Calculated pH	Percent Error
A	**6**	**6**					
B	**10**	**2**					
C	**7**	**5**					
D	**5**	**7**					
E	**2**	**10**					

5. Remove the cap from the pH meter and turn the pH meter on. Rinse the pH meter probe with approximately 10 mL of distilled water in a separate beaker or in your sink. Blot the pH probe with a clean paper towel.
6. Place the pH meter in the **Buffer A** solution to obtain the **measured pH**. You may have to pick up the beaker and tilt it so that the solution has enough depth to submerge the tip of the pH meter. It will take 30 – 60 seconds for the pH meter to achieve an accurate reading. **Record this value in the Measured pH column of Table 2.**
7. **Take a picture with your camera (or smartphone) of your pH meter in Buffer A to include in your Post-Lab,** making sure that the picture shows the labeled beaker and the

reading on the pH meter.

8. Rinse the pH meter with distilled water and blot with a paper towel between each buffer solution.
9. Repeat steps 6 – 8 for **Buffers B, C, D, and E**.
10. **Reserve the remaining sodium acetate solution for use in EXPERIMENT 2 (a minimum of 20 mL is needed for EXPERIMENT 2).**
11. Discard of the buffers in beakers A, B, C, D, and E down the sink and wash and dry the beakers for use in Experiment 2.

EXPERIMENT 2 – Testing the Buffering Effectiveness of CH_3COOH/ CH_3COONa

Part 1 – Re-calibrate pH Meter

1. Repeat Steps 4 – 7 of Experiment 1, Part A (Calibration of pH meter) with the pH 6.86 calibration solution.
2. Repeat Stepts 4-7 of Experiment 1, Part A (Calibration of pH meter) with the pH 4.01 calibration solution.

Part 2—Addition of Cola to Buffers

1. Use the 100 mL graduated cylinder to measure and pour 20 mL of **4.5% acetic acid** into a clean 100 mL beaker.
2. Rinse the 100 mL graduated cylinder with distilled water and dry it.
3. Use the 100 mL graduated cylinder to measure and pour 20 mL of **sodium acetate** solution **from Experiment 1** into the same 100 mL beaker to make 40 mL of a solution of a **CH_3COOH/ CH_3COONa** buffer solution. Stir with the clean, dry stir rod.

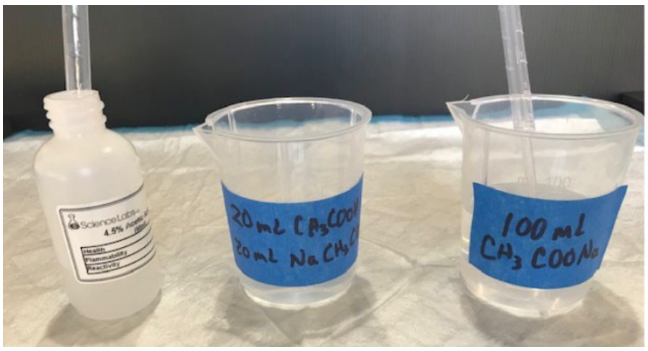

***Figure 8**. 40 mL of buffer solution composed of **4.5% CH_3COOH** and **CH_3COONa** (from Experiment 1).*

4. Rinse the 100 mL graduated cylinder with distilled water and dry.
5. Pour 20 mL (half of the solution) of the **CH_3COOH/ CH_3COONa** buffer solution into the 100 mL graduated cylinder and transfer into another clean 100 mL beaker.
6. Label the two beakers each, containing 20 mL of the CH_3COOH/ CH_3COONa buffer, as **"F" and "G".**

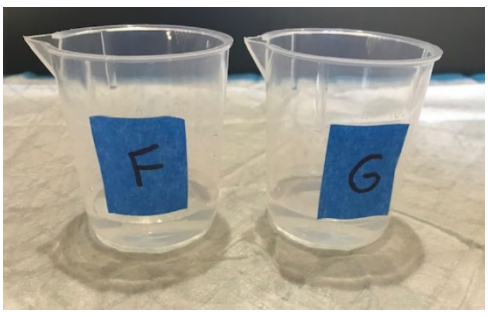

***Figure 9.** Beakers F and G, each containing 20 mL of the **acetic acid/sodium acetate** solution.*

7. Set aside Beaker G for use later in Experiment 2, Part 3.

8. Remove the cap from the end of the pH meter and rinse the probe with approximately 10 mL of distilled water. **Measure the pH of Buffer F and record the value in Table 3.**

Table 3. Change in pH of Buffers F and G Upon Addition of Cola

Buffer	pH (0 mL cola)	pH (5 mL cola)	pH (10 mL cola)	pH (20 mL cola)
F				
H			--	--

9. Rinse the pH meter with 10 mL distilled water.

10. Use a pipette labeled "**cola**" to transfer **5 mL of cola**® into a clean dry 10 mL graduated cylinder.

Note: Make sure to pipette the cola SLOWLY down the side of the graduated cylinder to avoid the production of bubbles. *Cola contains phosphoric acid and can be used to observe the effects of an acid on Buffer F.* If there is a significant amount of bubbles, tap the side of the cylinder GENTLY to dislodge and remove the excess bubbles.

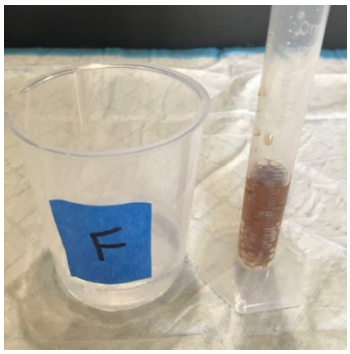

Figure 10. *Beaker F with* ***CH_3COOH/CH_3COONa*** *buffer and graduated cylinder with 5 mL cola. Note the bubbles in the cola that need to be removed for accurate measurement.*

11. Add the 5 mL of cola to **Beaker F and swirl gently to mix.** Measure the pH with the pH meter and **Record the new pH of the mixture of CH_3COOH/ CH_3COONa** buffer and 5 mL **cola in Table 3.**

12. **Take a picture with your camera (or smartphone) of your pH meter in the buffer solution, making sure that the pH reading is clearly visible, to include in your Post-Lab.**

13. Rinse the pH meter with 10 mL distilled water.

14. Use the "**cola**" pipette to transfer **another 5 mL of cola** into the 10 mL graduated cylinder and add this to Beaker F (*the solution should now have a total of 10 mL of cola*) and measure the pH with the pH meter. **Record the new pH in Table 3. Take a picture with your camera (or smartphone) of your pH meter in the buffer solution to include in your Post-Lab.**

15. Rinse the pH meter with 10 mL distilled water.

16. Use the "**cola**" pipette to transfer **another 10 mL of cola** into the 10 mL graduated cylinder and add this to Beaker F (*the solution should now have a total of 20 mL of cola*) and measure the pH with the pH meter. **Record the new pH in Table 3. Take a picture with your camera (or smartphone) of your pH meter in the buffer solution to include in your Post-Lab.**

17. Rinse the pH meter with 10 mL distilled water.

18. Label a clean 100 mL beaker **"H".**

19. Use a clean 100 mL graduated cylinder to measure and transfer 20 mL of distilled water into beaker H.

20. Rinse the pH meter with 10 mL distilled water then use it measure the pH of Beaker H. **Record the pH of Buffer H in Table 3.**

21. Use the "**cola**" pipette to transfer **5 mL of cola** into the 10 mL graduated cylinder and add this to Beaker H and measure the pH with the pH meter. **Record the new pH in Table 3. Take a picture with your camera (or smartphone) of your pH meter in the buffer solution to include in your Post-Lab.**

22. Discard the solutions in Beakers F and H down the drain with running water. Keep Beaker G for use in Part B. *Rinse out Beakers F and H and the 10 mL graduated cylinder with distilled water; then, dry with a paper towel.*

Note: You may wish to re-calibrate your pH meter one more time at this point in the procedure.

Part 3—Addition of Borax to Buffers

1. Use the scale to measure approximately **4 g of borax** into a weigh boat. Pour the borax into a clean, 100 mL beaker and label it **"borax".**

2. Use a clean, 100 mL graduated cylinder to measure and pour 100 mL of distilled water into the beaker with the borax powder. Use the stir rod to gently mix the solution. **See Figure 8**.

Hint: It may be difficult to get all of the borax to dissolve. If this is the case, you can gently heat the borax solution while you stir it. Fill a bowl or pan to about 2 inches with hot tap water and carefully hold your beaker of borax in the hot water, making sure that none of the hot water splashes into the beaker.

Note: This borax solution, which contains sodium borate, will be used to observe the effects of a base on the buffer in Beaker G (created in Part A).

Figure 11. *Preparation of borax solution from 4 g of* ***borax*** *powder and 100 mL distilled water.*

3. Remove the cap from the end of the pH meter and rinse the probe with approximately 10 mL of distilled water. **Measure the pH of Buffer G** (prepared in Experiment 2, Part 2) **and record the value in Table 4.**

Table 4. Change in pH of Buffers G and I Upon Addition of Borax Solution

Buffer	pH (0 mL borax soln)	pH (5 mL borax soln)	pH (10 mL borax soln)	pH (20 mL borax soln)
G				
I			--	--

4. Rinse the pH meter with 10 mL distilled water.

5. Use a pipette labeled "**borax**" to transfer **5 mL of borax solution** into a clean dry 10 mL graduated cylinder and then add the borax to Beaker G. Gently swirl the solution to mix.

6. Measure the pH with the pH meter and **Record the new pH of the mixture of CH_3COOH/ CH_3COONa** buffer and 5 mL borax **in Table 4.**

7. **Take a picture with your camera (or smartphone) of your pH meter in the buffer solution, making sure that the pH reading is clearly visible, to include in your Post-Lab.** 

8. Rinse the pH meter with 10 mL distilled water.

9. Use the "**borax**" pipette to transfer **another 5 mL of borax** into the 10 mL graduated cylinder and add this to Beaker G (*the solution should now have a total of 10 mL of borax*) and measure the pH with the pH meter. **Record the new pH in Table 4. Take a picture with your camera (or smartphone) of your pH meter in the buffer solution to include in your Post-Lab.** 

10. Rinse the pH meter with 10 mL distilled water.

11. Use the "**borax**" pipette to transfer **another 10 mL of borax** into the 10 mL graduated cylinder and add this to Beaker G (*the solution should now have a total of 20 mL of borax*) and measure the pH with the pH meter. **Record the new pH in Table 4. Take a picture with your camera (or smartphone) of your pH meter in the buffer solution to include in your Post-Lab.** 

12. Rinse the pH meter with 10 mL distilled water.

13. Label a clean 100 mL beaker **"I".**

14. Use a clean 100 mL graduated cylinder to measure and transfer 20 mL of distilled water into Beaker I.

15. Rinse the pH meter with 10 mL distilled water then use it measure the pH of the water in Beaker I. **Record the pH of Buffer I in Table 4.**

16. Use the "**borax**" pipette to **transfer 5 mL of borax** into the 10 mL graduated cylinder and add this to Beaker I and measure the pH with the pH meter. **Record the new pH in Table 4. Take a picture with your camera (or smartphone) of your pH meter in the buffer solution to include in your Post-Lab.** 

17. Discard the solutions in Beakers G and I down the drain with running water. *Rinse out Beakers G and I and the 10 mL graduated cylinder with distilled water; then, dry with a paper towel.*