LEARNING UNDEFEATED
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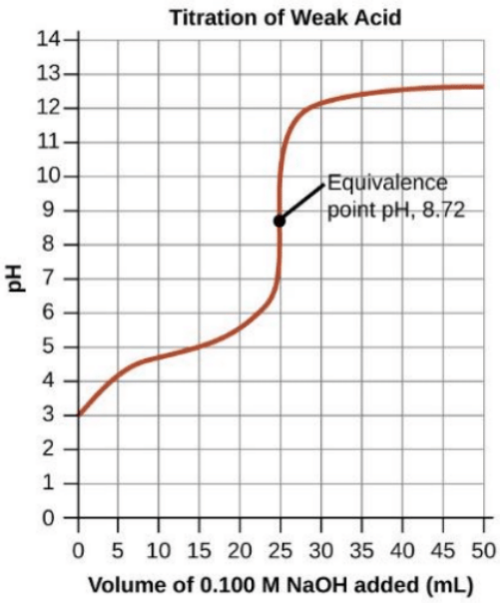
HANDOUT

The Sweet Spot:

Quality Control in Food Manufacturing

Name: _____

Learning Undefeated is releasing a new citrus sport drink called Zest Quest and with your background in chemistry, you have been hired to be the Quality Control Manager. As product comes off the line, it is your team's responsibility to ensure that it meets quality standards for safety and taste. Market research has found that most people find a very specific concentration of citric acid to be the best lemon flavor. When measuring concentration of acids we use molarity (M). Molarity measures how much of a substance, or the moles of a substance, are in one liter of solution. We can also represent molarity as an equation:



$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liters of solvent}}$$

The molarity of a substance can be determined through a process called acid-base titration. A titration is a way of determining the concentration of a substance by adding a known concentration of a reagent. Most titrations use visual indicators, like phenolphthalein or bromophenol blue, to signal when the titration is complete.

In our lab, we will add a known concentration of a strong base, sodium hydroxide (NaOH), to a small sample of our sports drink. We will add base slowly until we see a color change. The color change is due to a change in pH which we can observe by adding a pH indicator. When the mixture's color has been changed from clear to pink, then it has reached its equivalence point, and the acid has been neutralized.

$$3NaOH + H_3C_6H_5O_7(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3\,H_2O(l)$$

Sodium Hydroxide	*Citric Acid*	*Sodium Citrate*	*Water*

? Quick Check: What is the equivalence point?

Based upon the above reaction, what is the mol ratio of acid to base (i.e. how many mols of citric acid can be "neutralized" by only 1 mol of NaOH)? _____ (C)This is known as your molar ratio, which you will need to calculate the unknown.

+ MATERIALS

- 0.04 M NaOH
- Citric Acid Sports Drink (QC and U)
- Micropipettes and tips
- Phenolphthalein (pH indicator)
- Graduated Cylinder
- Water (H_2O)
- Burette
- 3 Collection Containers

+ PART I: USING A BURETTE

Burettes are used in titrations, as they allow us to add our titrant slowly, one drop at a time. A burette is a common piece of laboratory equipment comprised of a glass or plastic tube with a stopcock at the dispensing end.
When we measure using a burette, we measure the amount of liquid dispensed and represent that as the change in volume:

Final Volume Base – Initial Volume Base = Amount of Base Used

Burettes are read by recording the value at the bottom of the meniscus. It is important to view the measurement at eye level to get the most accurate value.

Practice Using a Burette

- [ ] 1. Label a small plastic cup with the letter P for practice and place under the burette.
- [ ] 2. The Burette is slightly over filled for practice. Slowly turn the stopcock vertically until the liquid is coming out one drop at a time.
- [ ] 3. Close the stopcock once your burette reads approximately 0 mL.
- [ ] 4. Record your initial value: _____mL

+ PART II: QUALITY CONTROL – TESTING PRODUCT ACIDITY

Our sports drink should contain 0.005M Citric Acid, the most favorable concentration shown through consumer studies. If we have a quality product, it should take between 3-4ml of 0.04M NaOH to neutralize all the acid.
To test this, we will use an acid base titration.

- [ ] 1. Label one of the collection containers FT (First Titration)
- [ ] 2. Using a graduated cylinder, add 10 mL of H_2O into the collection container.

- [ ] 3. Pour the H2O into the collection container
- [ ] 4. Add 250 µL of the sports drink into collection cup and swirl the contents together for 10 seconds.
- [ ] 5. Add 100 µL of the indicator, phenolphthalein (amber tube) into the collection container.
- [ ] 6. Swirl contents together for 10 seconds. Take note of the initial color of the solution.
- [ ] 7. Record the initial volume of the NaOH based on reading the burette in Table 1 below.
- [ ] 8. Position the collection container under the burette and slowly turn the stopcock towards vertical.
- [ ] 9. Add one drop at a time and swirl the collection cup with every additional drop. Pay attention for a color change.
- [ ] 10. When there begin to be flashes of pink color, slow down the addition of drops.
- [ ] 11. When the endpoint of a pink color change is achieved, meaning the liquid in the collection cup stays pink after swirling, turn the stopcock to a horizontal position to stop the titration.
- [ ] 12. Record the final volume reading of the burette in Table 1.

Table 1

Total Amount of 0.04M NaOH Added	
Final Reading in Burette	mL
Initial Reading in Burette	mL
Total Amount of 0.04M NaOH Added (V_{base})	mL

❓ Was your titration in the expected range? What do you think went wrong or right?

+ PART III: EMERGENCY ON THE FACTORY FLOOR

Our new global partnership with Fizzology Inc is supposed to start next week and we need to ensure we have a good product. We have no idea whether the machines added the proper amount of citric acid. If there is too much our product will be sour and if it is too low, it will taste bland.

It is now your job to identify whether we can send our product to store shelves or not by testing whether the citric acid is at the proper concentration. A bad product can set us back and can be the difference between thriving as a business or losing money.

- [ ] 1. Label one of the collection containers Exp (Experimental Titration).
- [ ] 2. Using a graduated cylinder, add 10 mL of H2O into the collection container.
- [ ] 3. Add 250 µL of the sports drink (U), which is our V_{ACID}, into collection cup and swirl the contents together for 10 seconds.
- [ ] 4. Add 100 µL of the indicator, phenolphthalein.
- [ ] 5. Swirl contents together for 10 seconds. Take note of the initial color of the solution.
- [ ] 6. Record the initial volume of the NaOH based on reading the burette in Table 2 below.
- [ ] 7. Position the collection container under the burette and slowly turn the stopcock towards vertical.
- [ ] 8. Add one drop at a time and swirl the beaker with every additional drop. Pay attention for a color change.
- [ ] 9. When there begin to be flashes of pink color, slow down the addition of drops.
- [ ] 10. When the endpoint of a pink color change is achieved, turn the stopcock to a horizontal position to stop the titration.
- [ ] 11. Record the final volume reading of the burette in Table 2.
- [ ] 12. Calculate total amount of NaOH added by subtracting the final burette volume from the initial burette volume.

Table 2

Total Amount of 0.04M NaOH (M_{BASE}) Added	
Final Reading in Burette	mL
Initial Reading in Burette	mL
Total Amount of 0.04M NaOH Added (V_{base})	mL

Calculate the concentration of your citric acid (M_{ACID}) using the formulas below:

$$3NaOH + H_3C_6H_5O_7(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3\ H_2O(l)$$

Sodium Hydroxide — *Citric Acid* — *Sodium Citrate* — *Water*

$$M_{ACID} \times V_{ACID} \times DF = M_{BASE} \times V_{BASE} \times C$$

CONVERSION FACTORS

DF (Dilution Factor) = $\frac{(V_{ACID} + V_{H_2O})}{V_{H_2O}}$

1 Liter = 1,000 mL = 1,000,000 µL

❓ What is your recommendation to the CEO about sending out the product?