

Exercise 4: A weak acid

The experiment you are not performing this week would have gone something like this:

Lab 2: Determination of K_a of a weak acid

Purpose: To determine the value of the dissociation constant for a weak acid

Skills:

- Use of a buret for precision volume measurement
- Use of a digital pH meter for quantitative determination of the acidity/alkalinity of a solution
- Understanding the role of approximations in equilibria

Chemical equation: $HA + OH^- \rightleftharpoons H_2O + A^-$ which is a neutralization but this isn't really the equation that the dissociation constant equation is based on. On second thought, please write the **chemical equation** that your calculation of K_a will be based.

Chemicals needed:

- 1.943 M unknown acid (record the letter of the acid)
- 1.002 M NaOH
- distilled water (dH_2O)

Equipment needed:

- Digital pH meter
- Several large test tubes
- Two burets with stopcocks

Special equations needed: $[H^+] = 10^{-pH}$

Procedure:

1. Fill the first buret with the unknown acid; fill the second buret with the NaOH solution.
2. Prepare the following solutions in different large test tubes:

Solution	Volume of unknown acid (mL)	Volume of NaOH (mL)	Volume of distilled water (mL)
#1	5.00	2.50	
#2	5.00	5.00	
#3	5.00	7.50	
#4	5.00	10.00	

3. Rinse out one of the burets and fill it with distilled water. Add enough distilled water to each large test tube to make the total volume 15.00 mL. Mix well.
4. Obtain and calibrate (if needed) a digital pH meter. In another table, record the pH of each of the four solutions. Make sure that you are rinsing the pH probe with distilled water in between measurements. Check with another group to make sure that you are getting sensible numbers.

Data and analysis

Solution	pH	[H ⁺]	[A ⁻]	[HA]	K _a
#1	4.30				
#2	4.79				
#3	5.29				
#4	12.31				

Calculations

1. Complete the final column on the table on the first page.

2. Write the full **equilibrium expression** for calculating K_a.

3. Calculate the [H⁺] for each solution and enter it in the table above.

4. How would you determine the next two columns in the table above (the [A⁻] and [HA] columns)? Filling in the table below may help:

Solution	Millimoles of HA initially	Millimoles of OH ⁻ initially	Millimoles of unreacted HA	Millimoles of A ⁻ made
#1				
#2				
#3				
#4				

5. Given that the final volume is 15.00 mL, fill in the [A⁻] and [HA] columns in the table.

6. Calculate K_a for each row in the top table.

7. Please comment on the consistency of K_a. *Should* it be consistent from row to row?

Conclusions

8. What would happen to your K_a if you forgot to add water to the test tubes, but recorded the final volume as 15.00 mL anyway?

9. The calculations are done assuming that the OH^- added is reacting completely with the acid. Suppose this were not the case (that not all of the OH^- added reacted completely); how would this affect K_a ? Show a brief calculation that demonstrates how K_a would change.