Acid/Base Chemistry: Titration Lab

THE FINAL FORMAL LAB ACTIVITY of the Chemistry 11 Course

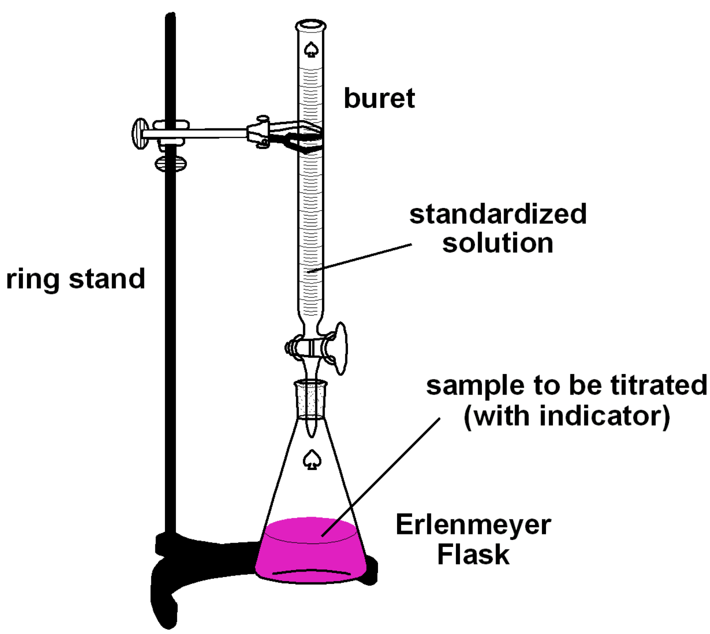
What is a Titration?

A titration is an analytical procedure used to determine the accurate concentration of a sample by reacting it with a standard solution. One type of titration uses a neutralization reaction, in which an acid and a base react to produce a salt and water:

$$HCl\ (aq) + NaOH\ (aq) \longrightarrow NaCl\ (aq) + H_2O\ (l) \qquad \textbf{(1)}$$

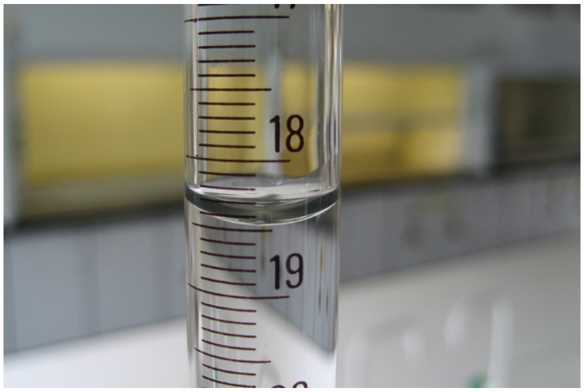
In equation 1, the acid is HCl (hydrochloric acid) and the base is NaOH (sodium hydroxide). When the acid and base react, they form NaCl (sodium chloride), which is also known as table salt. The titration proceeds until the **equivalence point** is reached, where the number of moles of acid (H^+) is equal to the number of moles of base (OH^-). The moles of acid and base are related by the stoichiometry of the balanced equation. This equivalence point is usually marked by observing a colour change in an added indicator. The moment where the colour of the indicator changes is called the **endpoint**.

In a titration, the standard solution (of known concentration) is in a buret, which is a piece of glassware used to measure the volume of solution to a great degree of accuracy. The solution that you are titrating (of unknown concentration, but the volume is accurately measured) is in an Erlenmeyer flask, which should be large enough to accommodate both your sample and the standard solution you are adding.

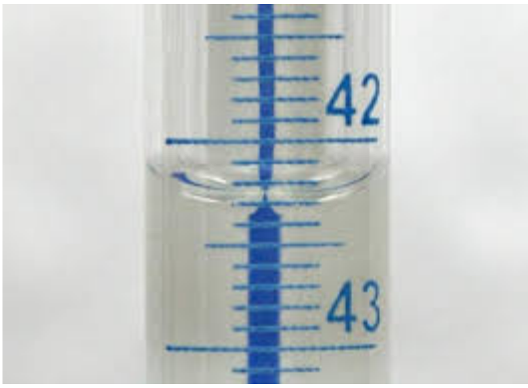


A buret is used because the volumes can be measured very precisely (± 0.05 mL).
(± ½ of the marking on the glassware).
Be sure you are reading volumes properly, from the *bottom of the meniscus.*

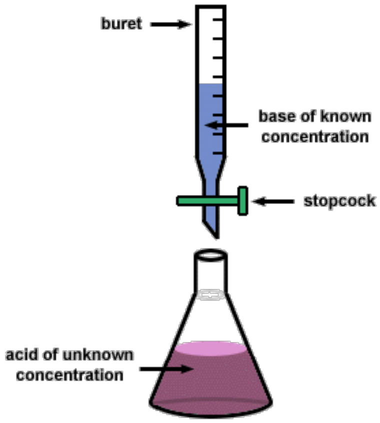
For example the volume on the buret below would be 18.50 ± 0.05 mL



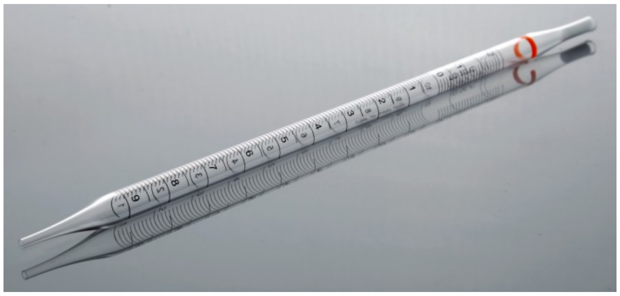
If this was your final volume reading on your buret, it would be 42.30 ± 0.05 mL



This volume information would be written in a data table like this:
INITIAL BURET READING: 18.50 ± 0.05 mL.
FINAL BURET READING: 42.30 ± 0.05 mL
TOTAL VOLUME OF NaOH used in the Titraion: $V_f - V_i$ = 42.30 – 18.50 = 23.80 ml



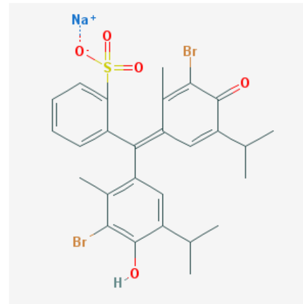
The acid is typically added to the Erlenmeyer flask in a specific volume (usually 10.0 or 25.0 mL) using a **pipette** which also measures volumes very precisely. The sample size (in mL) of the unknown is called an "aliquot."



A typical pipette

What is an Indicator and What is it Used For?

An indicator is any substance in solution that changes its colour as it reacts with either an acid or a base. Indicators are either weak acids or weak bases, often with complex chemical structures, that exhibit one colour when in acidic form, and another colour when in basic form.



Selecting the proper indicator is important because each indicator changes colour over a particular range of pH values.

ACID-BASE INDICATORS

Indicator	pH Range in Which Colour Change Occurs	Colour Change as pH Increases
Methyl violet	0.0 – 1.6	yellow to blue
Thymol blue	1.2 – 2.8	red to yellow
Orange IV	1.4 – 2.8	red to yellow
Methyl orange	3.2 – 4.4	red to yellow
Bromcresol green	3.8 – 5.4	yellow to blue
Methyl red	4.8 – 6.0	red to yellow
Chlorophenol red	5.2 – 6.8	yellow to red
Bromthymol blue	6.0 – 7.6	yellow to blue
Phenol red	6.6 – 8.0	yellow to red
Neutral red	6.8 – 8.0	red to amber
Thymol blue	8.0 – 9.6	yellow to blue
Phenolphthalein	8.2 – 10.0	colourless to pink
Thymolphthalein	9.4 – 10.6	colourless to blue
Alizarin yellow	10.1 – 12.0	yellow to red
Indigo carmine	11.4 – 13.0	blue to yellow

Titration Lab Procedure DAY ONE:

1. Rinse the burette with H_2O. (Check valve and seal; **DO NOT** put the buret under the water tap!! Use a beaker filled with H_2O to perform these rinses and then dump the water rinsings into the sink)
2. Rinse with <10 ml of NaOH. (Discard in waste container)
3. Fill the burette with NaOH until the meniscus rests at 0.00 ml.
4. Record the accurate molarity of the NaOH.
5. Obtain exactly 10.0 mL of HCl solution in Erlenmeyer flask.
6. Add 3-5 drops of bromthymol blue indicator to the Erlenmeyer flask.
7. Add the NaOH from the burette, slowly, dropwise, to the HCl sample in the Erlenmeyer. Keep one hand on the valve and the other hand constantly swirling the Erlenmeyer flask. This step must all be done by ONE PERSON at a time.
8. Stop when the indicator turns green.
9. Each person in the lab group must complete the titration steps 5 to 8.

You will likely NOT be successful the first time you try this, as you have no idea how many mL of NaOH it will take to neutralize your unknown acid sample.

Consider the following tips:

- Do a rough titration, adding ~1 mL of NaOH at a time to find the approximate volume needed for neutralization
-Once you have an idea of the volume at which the colour will change, then repeat the titration until you have 2 “good” results.
(Acceptable titration practice requires two results that are within 0.1 ml of each other)

CLEAN UP at the end of the titration:

Drain the NaOH out of the burette (discard unused solutions in waste container), and rinse the burette with water before putting it away. YOU CAN NOT LEAVE any NaOH inside the buret!!!!
Neutralized solution in the Erlenmeyer flask can be rinsed down the drain with H_2O
Rinse all glassware with water and put all glassware away (does not have to be dried).

Copy the data table below into your lab report:

<u>Titration of HCl</u>

Temperature (°C)	
Concentration of NaOH standard (M)	
Volume of HCl sample (mL ± ? mL)	
Titration Trial 1: volume of NaOH (mL ± ? mL)	
Titration Trial 2: volume of NaOH (mL ± ? mL)	
Titration Trial 3: volume of NaOH (mL ± ? mL)	
Titration Trial 4: volume of NaOH (mL ± ? mL)	
Average volume of NaOH (mL ± ? mL)	

Titration Lab Procedure DAY TWO:

If you are starting this lab on the next day, repeat steps 1 to 4 from the DAY ONE instructions.

5. Obtain __________ mL of ___________________acid in Erlenmeyer flask
6. Add 3-5 drops of ____________________ indicator
7. Add the NaOH from the burette, slowly, dropwise, to the acid sample in the Erlenmeyer. Keep one hand on the valve and the other hand constantly swirling the Erlenmeyer flask.
8. Stop when the indicator turns ________________.
9. Each person in the lab group must complete the titration steps 5 to 8.

Copy the table below into your lab report:

Titration of ____________________ acid

Temperature (°C)	
Concentration of NaOH standard (M)	
Volume of __________acid sample (mL ± ? mL)	
Titration Trial 1: volume of NaOH (mL ± ? mL)	
Titration Trial 2: volume of NaOH (mL ± ? mL)	
Titration Trial 3: volume of NaOH (mL ± ? mL)	
Titration Trial 4: volume of NaOH (mL ± ? mL)	
Average volume of NaOH (mL ± ? mL)	

Calculations:

Lab Day #1) Use the successful trials to calculate an average volume of NaOH used in the titration, and to calculate the concentration of the HCl solution.

Calculations:

Lab Day #2) Use the successful trials to calculate an average volume of NaOH used to titrate the unknown acid, and to calculate the concentration of the acid solution.

Get the Final [acid] for each part of the lab from TWO other lab groups.

Day 1 [acid] from two other groups: ____________ ________________

Day 2 [acid] from two other groups: ____________ ________________

You will be comparing your answer to other lab groups in your **Analysis of Accepted Value** section of your lab report to calculate a **Percent Deviation** (see Mrs. Toombs' Lab Report Format outline).

QUESTIONS: 12 marks!!!!!

Answer the following in FULL sentences in your lab report.
Be sure to elaborate with full detail to ***fully demonstrate your understanding*** of each concept.

1) You are given a known concentration of a potassium hydroxide solution and you are asked to find the concentration of an oxalic acid solution. Which solution(s) would you be putting in:

a) a buret
b) a graduated cylinder
c) an Erlenmeyer flask
d) a pipette

Justify, clearly, for each answer.

2) At the end of an acid-base titration, the products in the Erlenmeyer flask are always a ______ and ______. (Write the completed sentence in the response in your lab report.)
Explain why you can, or can NOT, dump the resulting solution down the sink drain.

3) Sometimes it requires less than a full drop of solution from the burette to reach the perfect indicator colour (and therefore the endpoint of the titration). Explain clearly why this is true.

4) Which of these scenarios would cause you to have to dump out your solutions and re-prepare you glassware? ***Justify, clearly, for each answer.***

i) The burette acquired from the lab cupboard had droplets of liquid in it and the students filled it with base anyway and started their titration.
ii) The Erlenmeyer flask had been rinsed with water after completing the first titration, and was wet when the next sample of acid was poured into it.

Full formal lab report is due: ____

Carefully follow the lab report guidelines, found on Mrs. Toombs' website.
This is your last Full Formal Lab mark for the year, so do your **best** work!
All sections of the lab report are required for this lab.
However, this lab will NOT require a graph.

The total marks for this lab will be **40 marks!!!**

The questions are worth 12 marks and the 3 part Discussion section is worth 9 marks so be sure to write thorough, elaborate explanations in these two parts of the lab report.

If the lab report is handed in after the due date, an additional two questions will be assigned. They will be worth 10 marks. Without completing these additional questions, you will not be able to score more than 30/40 on this lab report.

Marks

2	Proper Lab Report Format throughout
1	Purpose
1	Materials
3	Procedure
3	Observations
4	Data tables
4	Calculations
	Questions
4	1)
2	2)
2	3)
4	4)
3	Sources of Error
3	Analysis of Percent Deviation
3	Relevant Theory
1	Conclusion
40	

Late labs:

Total mark from above /40 will be scaled down to a mark /30
And then the 2 additional questions will be marked /10
and added to the /30 mark above to get a new total lab mark /40