Acid/Base Chemistry: Titration Lab

THE FINAL FORMAL LAB ACTIVITY of the Chemistry 11 Course

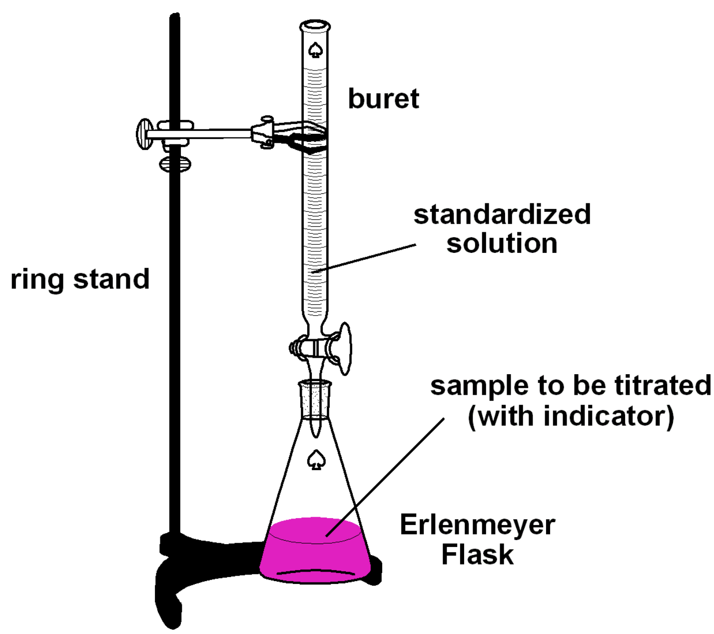
What is a Titration?

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**.

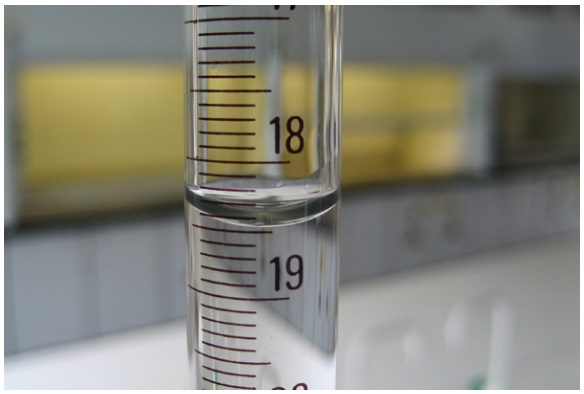
In a titration, the standard solution (of known concentration) is in a buret, which is a piece of glassware used to measure the volume of solution to a great degree of accuracy. The solution that you are titrating (of unknown concentration, but the volume is accurately measured) is in an Erlenmeyer flask,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



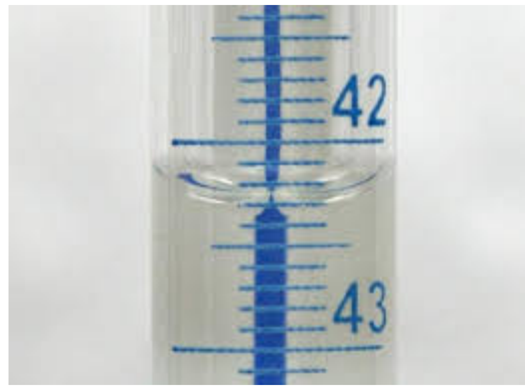
Please note:
In the Online Titration Simulator Activity that you will complete, the solution of KNOWN concentration is placed in the conical flask (usually an Erlenmeyer flask, but sometimes a beaker) and the solution of UNKNOWN concentration is placed in the BURET.
This set up is used especially when you are trying to determine the concentration of a solution to be standardized (in the buret).

A buret ***(can also be spelled burette)*** 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



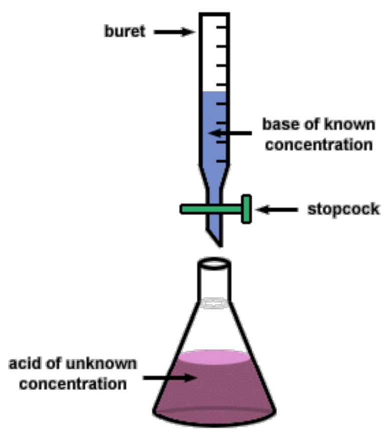
If this was your final volume reading on your buret, it would be 42.30 ± 0.05 mL

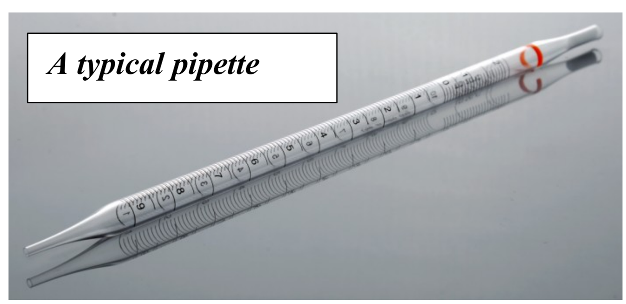


This volume information would be written in a data table like this:

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 following diagram shows a typical setup, where the buret contains the solution of known concentration, and the flask contains the solution of unknown concentration.



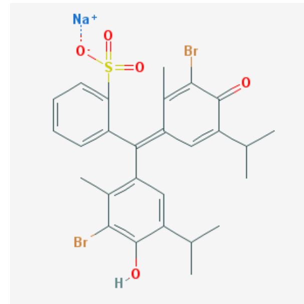


A typical pipette

The "standard" solution, of known concentration is typically added to the buret.
The solution of unknown concentration is typically added to the Erlenmeyer ("conical") flask.
A specific volume is added to the flask (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."

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.



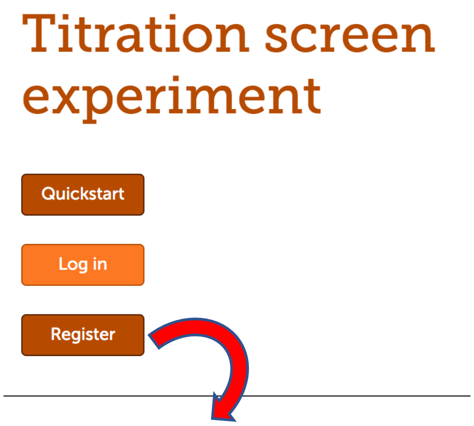
Selecting the proper indicator is important because each indicator changes colour over a particular range of pH values.

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

FIRST, READ THROUGH THESE INSTRUCTIONS

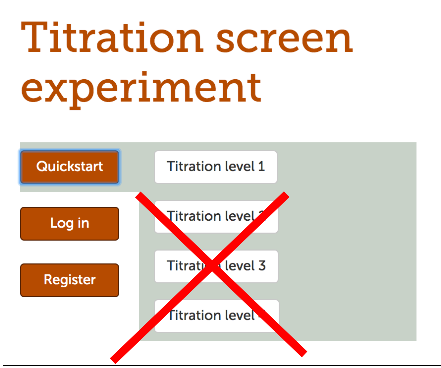
THEN, When you have an entire hour to devote to this activity,
Please go and complete the online TITRATION SIMULATOR:
CLICK HERE: http://www.rsc.org/learn-chemistry/resources/screen-experiment/titration/experiment/2



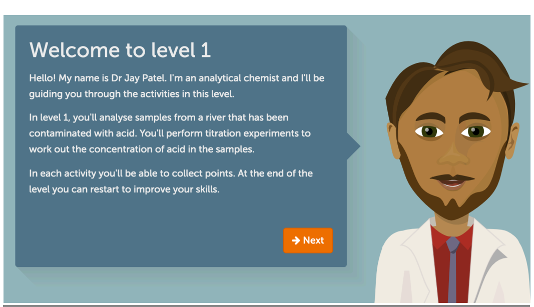
If you choose QUICKSTART, it will allow you to start without logging in.

HOWEVER, I RECOMMEND that you "Register." This will save your progress in case you cannot complete the activity all in one sitting. This will also allow you to review the work you have already done. ***It does NOT ask for any identifying data (no email address required.)***

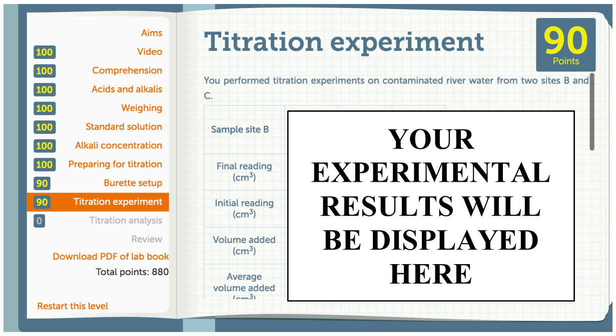
BE SURE TO RECORD YOUR USER NUMBER!!



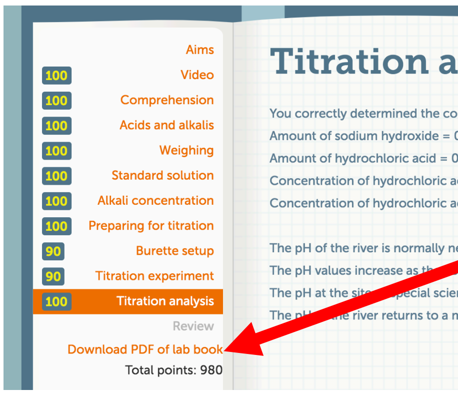
For Chemistry 11, you are only asked to complete Titration Level 1.
Levels 2 to 4 are for the Chemistry 12 course and will not make sense to Chemistry 11 students.
Each level takes about 45 minutes to 1 hour to complete.



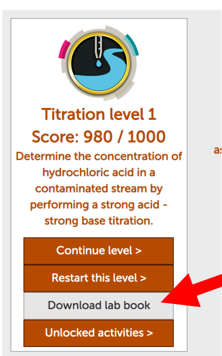
Make sure you read the instructions that pop up between each screen!
There is also valuable information pointed out on the right side of each laboratory step as you proceed.
This online lab is replacing in class instruction of the Acid-Base Theory that you need to learn about. This spectacular website teaches you about all of the core concepts and theories and also gives you the laboratory techniques that you need to know, going forward!
Please note that when you are carrying out the actual titrations, the REAL VIDEO of the solution in the flask is EXACTLY what you would observe if you were doing this lab experiment in person!



Throughout the activity, it will give you the options of downloading your lab book.
I recommend that you do that each time it offers that option.
This will allow you to review your results, rather than having to write them down.

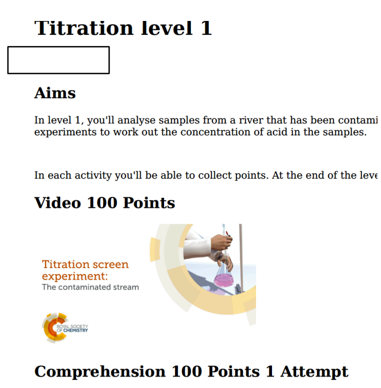


Note that when you finish the activity, it gives you the option of downloading the entire completed lab book.



You can also download the lab book from the HOME PAGE

This will give you a downloaded pdf of all of your results from Activity 1.



YOU HAVE THREE OPTIONS FOR OBTAINING MARKS FOR THIS ACTIVITY

OPTION ONE (see RUBRIC ON NEXT PAGE)

Write a full formal lab report, including ALL sections of a formal lab report.
(You will not have a graph nor an analysis of accepted values section).

Please note: *("decimeter cubed")* 1 dm^3 = 1 L and 1 cm^3 = 1 ml

DATA TABLE: (pay attention during the simulation and record this data).

Concentration of NaOH standard (M)	
Volume of HCl sample (mL)	
Titration Trial 1: volume of NaOH (mL)	
Titration Trial 2: volume of NaOH (mL)	
Average volume of NaOH (mL)	

You may insert a screen shot of your lab book data here instead of re-typing it!

Calculations:
Use the successful trials to calculate an average volume of NaOH used in the titration, and to calculate the concentration of each of the HCl solutions.

QUESTIONS:
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) In a lab activity in Mrs. Toombs' class next year in Chemistry 12, you are given a known concentration of a potassium hydroxide standard solution and you are asked to find the concentration of an unknown oxalic acid solution. Which solution(s) would you be putting in:

a) a burette 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

RUBRIC FOR OPTION ONE FORMAL LAB REPORT

1	**Entire lab report is TYPED.**
2	Proper Lab Report Format was followed throughout.
1	Purpose
1	Materials
3	Procedure
3	Observations
4	Data tables (might be screen shots from your online activity)
4	Calculations (might be screen shots from your online activity)
	Questions
4	1)
2	2)
2	3)
4	4)
3	Sources of Error
3	Relevant Theory
1	Conclusion
38	

This is the last chance in the course to use a lab report mark as a way to omit previous, lower lab report marks in this course.

OPTION TWO - Complete only this ALTERNATE set of questions as a 12 mark assignment.
DO NOT DO THE FULL LAB REPORT.

Choosing this option means that a lower lab report mark completed previously in the year will NOT be omitted.

Answer the following in FULL sentences. Hand in your typed answers.
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 make your own acetic acid solution and determine its concentration.
Which solution(s) would you be putting in:

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

Justify, clearly, for each answer.

2) Explain what is present at the end of a titration, in the flask that is placed below the burette? What can be dumped down the drain and what cannot be, at the end of a titration experiment? Clearly **explain why in each case**. Be thorough and detailed in your answer!

3) Explain why different experimenters might state a different volume in the burette that was required to reach the perfect indicator colour (and therefore the endpoint of the titration). Explain clearly why it is nearly impossible to have the same answers as other students.

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 was not rinsed before students filled it with the standard base solution.
ii) The Erlenmeyer flask (or beaker placed below the burette) had been rinsed thoroughly with water after completing the first titration, and was reused for the second titration, rather than acquiring a new, clean, dry beaker.

RUBRIC:

SCORE OF 11 – 12 out of 12:
Answers were typed, or a pdf was made of your *clear and neat* handwritten answers. Submitted answers to ALL questions. No answers were missing. FULL sentence answers. Elaborated with full detail to fully demonstrate your understanding of each concept.

SCORE OF 5 or less	**SCORE OF 6 – 7**	**SCORE OF 8 – 10**
Missing more than three of the required bullet points	Missing more than two of the required bullet points	Missing one or two of the required bullet points

OPTION THREE - **12 mark creative assignment.**

This will NOT replace lower lab reports completed previously in the year.

Can only be completed **instead of** OPTION 1 or OPTION 2.

If students REALLY want to complete this assignment **IN ADDITION** to OPTION 2,
please message Mrs. Toombs first!!!!

Read this article:
https://chronicleflask.com/2020/04/18/easy-indicators/

First, make the indicator. There are recipes online, but some of them are over-complicated. All you really need to do is finely chop the red cabbage leaf, put it in a mug, and pour boiling water over it. Leave it to steep and cool down. Don't accidentally drink it thinking it's your coffee. ☺ Pour off the liquid. Done.

Note that if you don't have an old cabbage leaf, there are other options suggested in the article, such as a tulip petal, poinsettia (poisonous!), Hydrangea, even turmeric!

RUBRIC:

SCORE OF 11 – 12 out of 12:
Submitted a single page or single image. Creative / artistic display of results. (Showing the ART in Science!) Clearly indicates how the experiment was carried out. Clearly indicates how results were determined. *Graphical picture (possibly accompanied by a labeled drawing) of the final results.* Clearly labeled what was used for the indicator solution. Clearly labeling what each tested substance was. Shows a wide range of tested substances and results. Results are arranged and displayed in a logical order / manner.

SCORE OF 5 or less	**SCORE OF 6 – 7**	**SCORE OF 8 – 10**
Missing more than three of the required bullet points	Missing more than two of the required bullet points	Missing one or two of the required bullet points