Titrations Worksheet and Lab

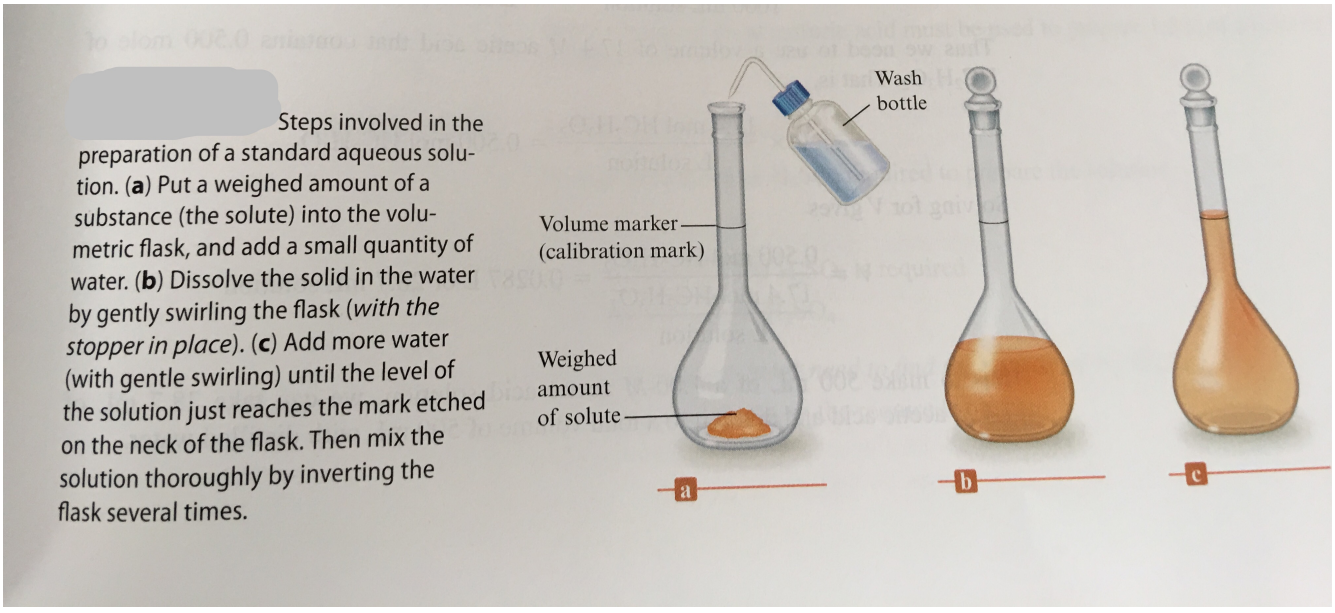
Vocabulary

1. Buret: a piece of glassware used for dispensing accurate volumes, generally reads to two places of decimal.
2. Titrant: the substance of known concentration added to the analyte in a titration
3. Analyte: the substance of unknown concentration
4. Equivalence point: the point in a titration at which neutralization occurs (specifically when number of **moles H^+ = number of moles OH^-)**
5. End point: the point in a titration at which there is a sudden change in physical property, such as indicator color change
6. Indicator: a compound having a physical property (usually regarding coloration) that changes abruptly near the equivalence point of a chemical reaction at specific pH
7. Standard solution: a solution whose concentration is known as well as the amount used in the titration
8. Neutralization reaction: a reaction between an acid an a base that yields salt and water

Making a Standard Solution

a. Making a Standard Solution starting from solid:

1. Calculate the mass of the solute needed.
2. Obtain the mass of solute needed and mass it in a weighing boat.
   -Make sure to zero the scale first for easier solute massing.
3. The solute is transferred to the volumetric flask
4. The weighing boat is then rinsed with distilled water.
5. The solution is swirled gently, and once all of the solute is dissolved, use DI water to make up the volume to the mark.
   -Be careful! Do not spill or go over the mark. You will need to start over!!!



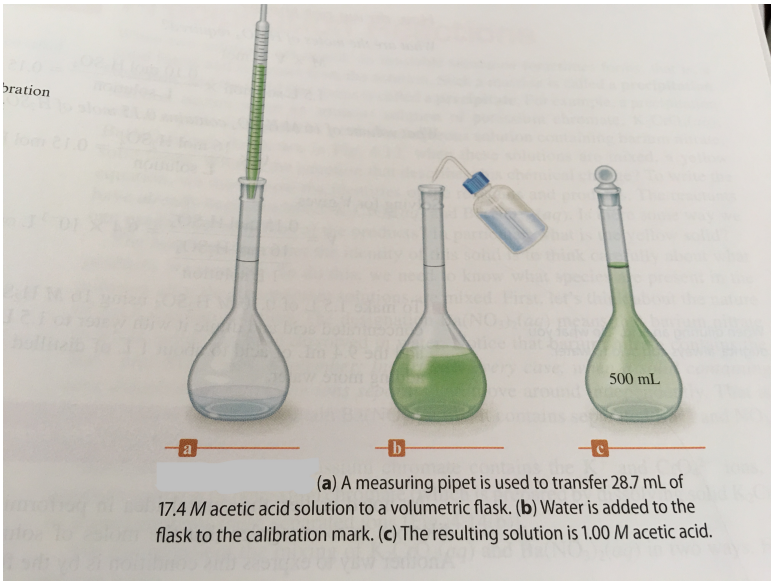
Credit: Zumdahl

b. Making a Standard Solution starting from a liquid (Dilution)

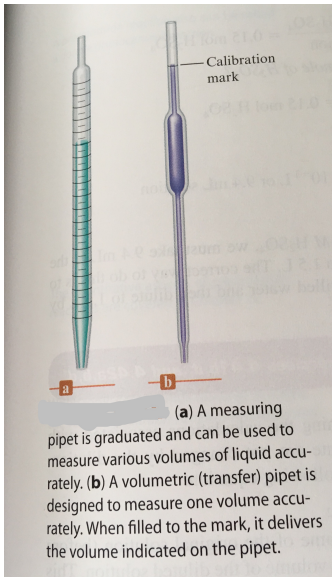
1. Calculate the volume of the concentrated solution to be diluted using $M_1V_1=M_2V_2$ equation. Transfer this amount of liquid to a clean volumetric flask using either graduated cylinder or pipet. If you are

diluting an acid, then be sure to put little water first in the flask before adding concentrated acid. (AAA= Always Add Acid to water).

2. Now, make up the volume to the mark with DI water.
   -Be careful! Do not spill or go over the mark. You will need to start over!!!



(**a**) A measuring pipet is used to transfer 28.7 mL of 17.4 *M* acetic acid solution to a volumetric flask. (**b**) Water is added to the flask to the calibration mark. (**c**) The resulting solution is 1.00 *M* acetic acid.



(**a**) A measuring pipet is graduated and can be used to measure various volumes of liquid accurately. (**b**) A volumetric (transfer) pipet is designed to measure one volume accurately. When filled to the mark, it delivers the volume indicated on the pipet.

Credit: Zumdahl

Strong Acid-Strong Base Titration Principle

The acid has completely reacted with (neutralized) the base. This is called the titration point, where the pH of the solution is 7, which means that it is a neutral solution.

$HCl + NaOH \rightarrow H_2O + NaCl$

Net Ionic Equation: $H^+ + OH^- \rightarrow H_2O$

Titration Using a Buret

A buret is used to precisely dispense a measure of an analyte in a titration until the end point of the reaction is reached.

Tips:

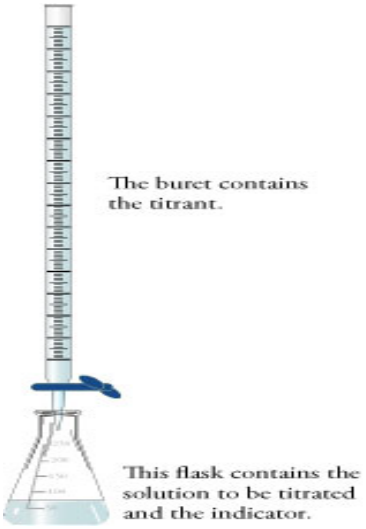
- Use one hand to swirl the flask while the other hand controls the stopcock.
- Make sure the stopcock is closed when you are not titrating.
- Bring the buret down to eye level for precise measurements.
- Use the funnel to add small portions to the titrant for rinsing.

Procedure:

1. To fill a buret, close the stopcock at the bottom and use a funnel.
   a. You may need to lift up on the funnel slightly in order to allow the solution to flow in freely.
2. Before titrating, it is imperial to condition the buret with titrant solution and check that the buret is able to flow freely.
   a. To condition the buret, rinse it so that all surfaces are coated with titrant solution, and then *drain through the stop cock*. Be sure to condition the buret three times to insure that the concentration of titrant is not affected by impurities such as stray drops of water.

   b. Check the tip of the buret for an air bubble. To remove air bubbles, lightly tap the side of the buret tip while the solution is still flowing. If an air bubble is present during the titration, you may have errors in your volume readings because any drops are considered deliberate volume.
3. The tip of the buret is then rinsed with water from a DI water bottle.
   a. Check if your buret is leaking. The tip should be clean before you take an initial volume reading.
4. The titrant is poured slowly so that the burette does not overflow. The funnel should be removed after filling the buret.
5. The initial volume is recorded to two decimal places.
6. Two to three drops of indicator are added to the analyte.
7. The flask is placed under the buret with some of the standard solution.
8. A rough titration is carried out to determine the relative volume needed.
   a. This step is to gauge the amount of volume needed to reach the end point so that you know when to stop the second time you do the titration.
9. The flask is placed under the buret with some of the standard solution.
10. The buret is adjusted so that the tip is inside the volumetric flask to avoid loss of titrant solution.
11. The titrant is added with constant swirling.
    a. When the solution shows signs of coloration (color depends on indicator), slow the speed at which the titrant is being added and stop when the solution has been lightly colored for 10 minutes (color is persistent). The endpoint should be approached slowly.
12. DI water is used to rinse the sides of the flask and the tip of the buret to be sure that all of the titrant is mixed in the flask.
    a. There should be a partial drop remaining in the tip of the buret.
13. The volume titrated is the difference between initial and final volume.
    a. Volume titrated (mL) $= V_f - V_i$
14. Use the formula, $C_1V_1 = C_2V_2$, to find the concentration of the titrant solution.

Setup for a Typical Titration Using a Buret



Credits:

Gupta 2017

"ChemLab - Techniques - Titration." *ChemLab - Techniques - Titration*. Web. 22 Sept. 2015. <http://www.dartmouth.edu/~chemlab/techniques/titration.html>.
"Titration Problems." *Titration Problems*. Web. 22 Sep. 2015. <http://preparatorychemistry.com/bishop_titration.htm>.

Titration Questions AP Chemistry
Level 1:

1) How many g of NaOH is required to completely react with 100. mL of 1M HCl? **Ans**: 4.0 g
2) How much water must be added to a solution that contains 100.0 g NaOH in 500. mL of solution to make the final concentration 2.00 M? **Ans**: 0.75 L water
3) How many liters of 3.4 M HI will be required to reach the equivalence point with 2.1 L of 2.0 M KOH? **Ans**: 1.2 L
4) 32.00 g of sodium hydroxide were dissolved in 250.0 mL of solution to prepare the titrant. 25.00 mL of sulfuric acid were titrated with above titrant. It took 16.00 mL of sodium hydroxide solution to titrate to the end point. What is the molarity of the sulfuric acid? **Ans**: 1.024 M
5) Can I titrate a solution of unknown concentration with another solution of unknown concentration and still get a meaningful answer? Explain your answer in a few sentences.
   Ans: Titration cannot be done without molality of at least one of the substances. In order to solve $M1V1 = M2V2$ both molarities cannot be unknown.
6) How many moles of HCl are needed to neutralize 1.0 L of 2.0 M NaOH? **Ans**: 0.20 mol of HCl needed
7) If it takes 15.0 mL of 0.40 M NaOH to neutralize 5.0 mL of HCl, what is the molar concentration of the HCl solution? **Ans**: 1.2 M

Level 2:

8) How many mL of a 3M NaOH solution are required to completely neutralize 20.0 mL of 1.5 M H_2SO_4? (Start by writing a balanced equation!) **Ans**: 20.0 mL
   Draw a particulate level drawing of this titration at equivalence point.

STRONG ACID- STRONG BASE (SA-SB Titration Lab)

SA-SB Titration	HCl	NaOH
	Analyte	Titrant
	(unknown conc)	(known conc)

Moles of H^+ = Moles of OH^- (at equivalence point)

There are three parts to this strong acid- strong base titration lab:

1. Making the standard solution

   Make 0.1molar NaOH a) from solid b)from liquid
2. Standardizing the NaOH with a solid acid (KHP or potassiumhydrogen phallate)

   To make sure what is the EXACT, molarity of our prepared NaOH 0.1M
3. Titrate standardized NaOH with unknown molarity HCl

Find molarity of HCl

Titration Prelab

1. Define the following terms related to titration
   a. Analyte

   b. Titrant

   c. Standard Solution

   d. Equivalence Point

   e. End Point

   f. Indicator

   g. Buret

   h. Volumetric Pipet

   i. Erlenmeyer Flask

2. Draw and label equipment set up and particulate level drawing at each step.
   a. Making 125 ml of standard solution of 0.1 M NaOH from NaOH pellets (solid)

Equipment Set Up

Particulate-level Drawing

Steps involved during this process

Any precautions during this step:

   b. Standardizing the standard solution with KHP

Equipment Set Up **Particulate-level Drawing**

Steps involved during this process

Any precautions during this step

c. Titration of unknown HCl with standardized NaOH

Particulate-level Draw- at the beginning of titration

Particulate level drawing at equivalence

Particulate level drawing -past equivalence

Post lab Questions

1. Write the complete chemical equation for the reaction of a solution of sodium hydroxide (NaOH) with hydrochloric acid (HCl).

2. How many mL of 0.1 M HCl are required to react completely with 5 mL of 0.1 M NaOH?

3. If equal molar amounts of NaOH and HCl are mixed, what will be the chemical species after reaction is complete?

4. Write the complete chemical equation for the reaction of a 0.1 M solution of acetic acid ($HC_2H_3O_2$) with 0.1 M solution of NaOH.

5. How many mL of 0.1M NaOH solution will be required to react completely with 5 mL of 0.1 M acetic acid ($HC_2H_3O_2$) solution?

6. How is it possible to determine when an acid-base reaction is complete when the concentration of one of the reactants is unknown?