Titration Calculations

This formula is used to solve all Titration Calculations:

$$\text{Molarity}_1 * \text{Volume}_1 = \text{Molarity}_2 * \text{Volume}_2 = \frac{g_2}{Mw_2} = \text{Number of Moles}$$

$M_1V_1 = M_2V_2$ is used when you are titrating one liquid against another such as NaOH solution vs vinegar.

$M_1V_1 = g / Mw$ is used when you are titrating one liquid against a solid such as NaOH vs Potassium Hydrogen Phthalate (KHP) for standardizing the NaOH

There are several concepts that you need to understand in using Titrations:

1. How do you prepare a stock solution of concentrated NaOH [1.0 L of 10 M NaOH]
2. How do you dilute down that stock solution to a working solution for use in the lab [1.5 L of 0.120 M NaOH]
3. How do you determine the exact concentration of the diluted NaOH[titrate it against KHP Standart]
4. How do you now use this standardized NaOH in a titration against an acid [titrate it against HCl or Vinegar].

Example 1: To standardize or calibrate NaOH, you titrate the NaOH [which is a base] against KHP [which is an acid].

You put the KHP and phenolphthalein, the indicator, in the erlenmeyer flask and titrate it against NaOH in the burette.

Problem 1: Determine how much KHP to weigh out?

Assume you are using a 50.00 ml burette. You want to use about 35.00 ml of the NaOH solution in the titration. You do not want to refill the burette, as that would add error to the calculations, so you do not want to use more than 35-40 ml in your original calculations. From the above equation, we can derive:

Grams of KHP = Molarity of the NaOH * Volume of NaOH * Mw of the KHP.

Assume the NaOH was made up to be approximately 0.100 Molar. Then

Grams of KHP = 0.100 Molar * 35.00 ml * 1. L / 1000. ml * 204.44 g/mole

Grams of KHP = about 0.7 grams of KHP.

So, we accurately weigh out approximately 0.7 g of KHP. Put this in a 250 ml Erlenmeyer Flask and add about 50 ml of distilled water. Warm [Not Boil] the solution until the KHP dissolves, then cool it down to room temperature. Add a few drops of the phenolphthalein indicator. Rinse the burette, using a funnel to fill it, several times with a few ml of the NaOH solution to season the burette. Then fill it with the NaOH solution to a level between 0.00 and 1.00 ml. You do not have to fill it exactly. Remove the funnel and allow the NaOH to finish dripping down. Take a reading on the burette remember you must read it to the second decimal. Examples: 0.45 ml, 0.50 ml. Start your titration, continue to swirl the Erlenmeyer flask. The titration is

complete when ½ to one drop turns the color of the solution from clear to pink. Take a reading on the burette again. Subtract the starting reading and this is now the volume of NaOH used in the titration.

Calculate the Molarity of the NaOH by: $\text{Molarity}_1 = \frac{g_2}{\text{Molecular Weight}_2 * \text{Volume}_1}$.

And remember, the Molarity of a solution is: $\text{Molarity} = M = \frac{\text{Moles}}{\text{Volume}} = \frac{g / Mw}{\text{Volume}}$

Example 2: Titrating an unknown strength acid in the beaker against standardized NaOH in the burette.
Use this formulae when your titrating one liquid against another liquid. If you have the concentration and volume of one solution and the volume of the second, then the concentration of the second is determined from:

$$\mathbf{Molarity_1 * Volume_1 = Molarity_2 * Volume_2}$$

$$Molarity_1 = \frac{Molarity_2 * Volume_2}{Volume_1}$$

When you use this technique, you will usually pipette the acid into the Erlenmeyer flask. Pipettes are extremely accurate. They come in various sizes: 1, 2, 5, 10, 20, 25 ml and their accuracy is marked on the side:

For a 25 ml pipette, the reading may be: TD 25^o 0.004 which means this pipette is a To Deliver at 25 ^{o}C 25 ml +/- 0.004 ml

Preparing a Stock Solution of NaOH

You have just been hired as the stock room technician. You were asked to make up 1 Liter of concentrated Sodium Hydroxide solution, or a stock solution. This solution is to be around 5.00 Molar. From the above equations we get:

Grams of NaOH = Molarity * Volume * Mw = 5.0 M * 1.00 L * 40.00 g/mole = 200. G

We weigh out approximately 200. Grams [199 – 201 g] of NaOH and place it in a 1 Liter Volumetric Flask. We 1/3 fill the flask with distilled water. The solution is stirred and carefully warmed to dissolve all of the NaOH. The solution is cooled back to room temperature and water is added to fill the Volumetric to the 1 Liter Mark.

The exact concentration of the NaOH is determined by the titration method described above in Example 1. Assume for further work that the concentration of this solution is 4.98 M.

Preparing a diluted working solution from the stock solution

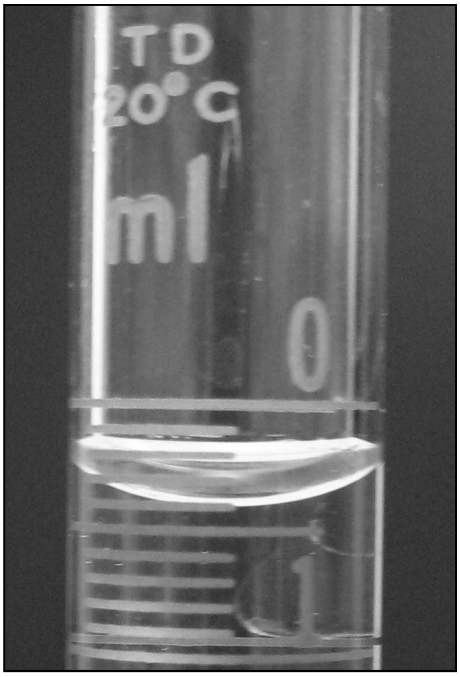
You are now asked to make up 2 Liters of approximately 0.0100 M NaOH for lab use from the stock solution. From the above equations we get:

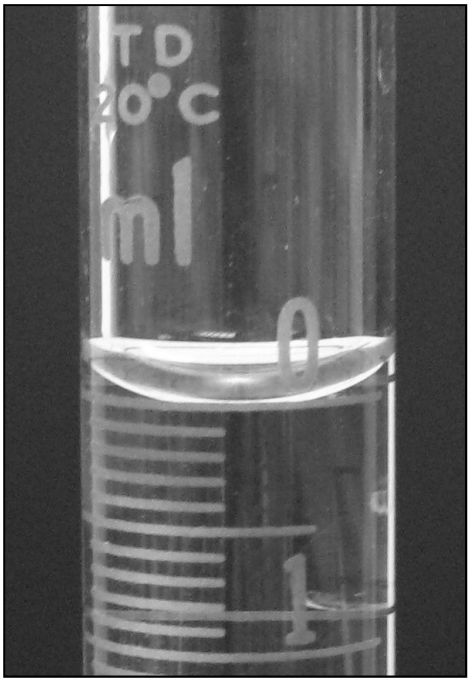
$$V_{Conc} = \frac{V_{dil} * M_{dil}}{M_{Conc}} = \frac{2.00\ L * 0.0100\ M}{4.98\ M} = 0.004016\ L = 4.0\ ml$$

So the procedure is to pipette [or you can use a burette, or an accurate graduate cylinder] 4.0 ml of the NaOH Stock Solution into a 2 Liter Volumetric Flask. Fill the flask to the mark with distilled water with stirring. Now accurately determine the concentration of the NaOH using the method in Example 1.

Reading a Burette

Burettes are calibrated with the ZERO reading at the top, and the FIFTY ml reading at the bottom. Yes, they are meant to be this way!





Reading the Burette: Burette reading involves reading all of the marked lines [ml and tenths of an ml] and interpreting the reading between two lines for the 0.01 ml reading.

The correct reading for the burette on the left is:	0.40 ml	0.4 is incorrect
The correct reading for the burette on the right is:	0.00 ml	0, 0. or 0.0 is incorrect.

Using the Burette:

1. Fill the Burette close to the zero reading. If you use a funnel to fill the burette, remember to remove the funnel prior to reading the burette. Leaving it could add an additional drop after you've read the burette. You do not have to fill the burette to zero.

2. Take a start burette reading. ALL READINGS are to TWO places after the decimal:

Correct Readings:	1.23	0.12	0.00	10.00 [ml]
Incorrect Readings:	1.2	0.1	0.	10.

3. Perform your titration.

4. Take the second reading. See the note above about reading to two places after the decimal.

5. Subtract the first reading from the second and you have the volume used in the titration.

6. Then refill the burette.

Using a Pipette

The pipettes we use in a Chemistry Lab are "TD" or "To Deliver" pipettes. They are calibrated To Deliver the said amount, if properly used. Each pipette is labeled [example 25 ml pipette] "TD 22 sec 20 ^{o}C Tol +/- 0.06" or something similar. TD = To Deliver. 22 sec = it will drain in 22 seconds with distilled water. 20 ^{o}C = the calibration is for that temperature. Tol +/- 0.06 = the tolerance of this calibration shows it will deliver 25.00 ml +/- 0.06 ml, or 0.24% accuracy.

1. Do Not push or set the pipette down on its tip, you could break off or crack the delivery tip
2. Use a pipette syringe or bulb to fill the pipette – not your mouth!
3. Fill the pipette to a location above the delivery mark. Then, either using your finger over the open end or the pipette syringe, slowly lower the liquid level until the bottom of the meniscus is at the delivery mark.
4. Then remove the pipette from the solution and WIPE OFF THE TIP with a Kim Wipe. This will remove excess solution.
5. Holding the pipette upright, remove your finger and let the pipette drain into the receiving vessel.
6. After the last drop has come out of the pipette, count 10 seconds, then touch the pipette tip to the side of the vessel to remove the last remaining drop.

DO NOT blow the pipette out with a bulb or syringe. If there are liquid drops still in the pipette, then the pipette MUST BE CLEANED, it is not accurate and has lost its calibration. When done pipetting, immediately wash the pipette out with water then distilled water and return it in an upright position such as in a large heavy Erlenmeyer flask to drain. Upright, it cannot roll off the table.

DO NOT pipette from a "Standard" or "Sample" bottle, you will contaminate the solution in the bottle. Pour an amount from the bottle into a beaker and fill the pipette from the beaker. If you are seasoning the pipette, do not fill and empty the pipette into the same beaker. You will contaminate and dilute the solution in the beaker.