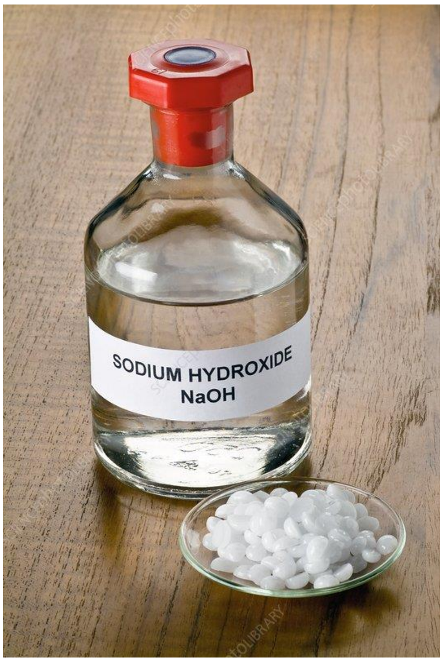
Friday worksheet 7 – volumetric analysis

1. A 20.00 mL aliquot of a solution of sodium hydroxide, from an unlabelled bottle of the solution, was added to a 100 mL conical flask, with two drops of appropriate indicator and titrated with a 0.121M solution of hydrochloric acid.

   Three trials were carried out and the volumes of the standard HCl solution titrated in each trial are shown below.
   12.01 mL, 11.95 mL, 12.04 mL



   a. Is there any result that should be discarded in the calculation of the average titre? Justify your answer..
   No. They are all concordant. The lowest differs from the highest by ni=o more than 0.10 mL.

   b. Calculate the average titre.
   (12.01 mL + 11.95 mL + 12.04 mL/3 = 12.00 mL

   c. Calculate, to the right number of significant figures, the mol of HCl in the average titre.
   mol = C X V = 0.01200 L X 0.121 mol/L = 1.45 X 10^{-3}

   d. Calculate, to the right number of significant figures, the mol of NaOH in the conical flask by first writing a balanced chemical equation for the reaction taking place in the flask.
   NaOH(aq) + HCl)aq) → H_2O(l) + NaCl(aq)
   The mol ratio between NaOH and HCl is 1:1, hence mol of NaOH = 1.45 X 10^{-3}

   e. Calculate, to the right number of significant figures, the concentration in mol/L of the sodium hydroxide solution contained in the bottle
   1.45 X 10^{-3} mol of NaOH came from 20.00 mL of solution
   => 1.45 X 10^{-3} / 0.0200 = 7.26 X 10^{-2} M

   f. Suggest how the following adjustments to the procedure may impact the final calculation of the concentration of NaOH. Circle the right response and justify your answer for each.

      i. Three drops of indicator are added to the conical flask.
      (impact = higher, lower, unchanged)
      One extra drop of indicator should not make any difference. However, since most indicators are themselves acids a significant volume of indicator can impact the result, in this case it will lower the titre and cause an underestimation of the concentration.

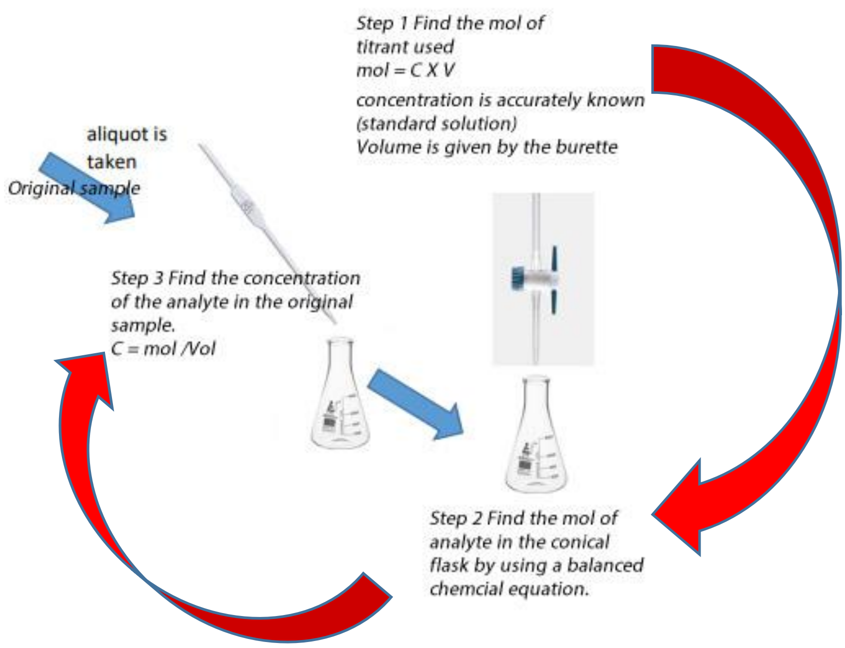
      ii. 1.0 mL of distilled water was used to rinse the burette.
      (impact = higher, lower, unchanged)
      Since water in the burette will dilute the standard solution of HCl it will cause more titrant to be added and hence cause an overestimation of the concentration of NaOH.

iii. 1.0 mL of the unknown NaOH solution was used to rinse the glass instrument used to deliver the 20.00 mL aliquot.
(impact = higher, lower, unchanged)

All instruments must be rinsed with the solution that will be placed in each during the titration. Of course water can be used to rinse only two pieces of glassware the conical and volumetric flasks. Since the pipette will be delivering the NaOH solution then it should be rinsed with the solution it will be transferring.

iv. 12.00 mL of distilled water is used to rinse the conical flask between trials.
(impact = higher, lower, unchanged)
As long as the right amount of volume of analyte, NaOH, is delivered into the conical flask adding water should not impact the reaction between the analyte and titrant and hence the end point should remain unchanged.

Since this question required no dilution of the original sample before titration only three steps are required, as shown on the right.
step 1 - find the mol of titrant by using the concentration of the standard solution and the average titre.
Step 2 - find the mol of analyte by using the stoichiometric ratio from a balanced chemical equation
Step 3 – find the concentration of the analyte in the original sample by using the mol of analyte in the conical flask and the volume from which it came from.



2. Hydrogen sulfide, H_2S, can cause an unpleasant smell in water supplies. The concentration of hydrogen sulfide can be measured by titrating with a chlorine standard solution. The equation for the reaction taking place is

$$4Cl_2(aq) + H_2S(aq) + 4H_2O(aq) \rightarrow SO_4^{2-}(aq) + 10H^+(aq) + 8Cl^-(aq)$$

10·00 mL of contaminated water was placed in a 200 mL volumetric flask and made to the mark with distilled water. Several 20.00 mL samples were prepared and titrated using a 0·0100 mol l^{-1} chlorine solution. The following titres were obtained.
20.87 mL, 20.94 mL, 21.01 mL, 21.06mL, 21.03 mL

a. Name an appropriate piece of apparatus which could be used to measure out the water samples. *A 20mL pipette*

b. What is meant by the term standard solution?
It is a solution which has a very accurately known concetration.
c. Calculate the average titre of 0·010 mol l^{-1} chlorine solution that was required to reach the end point.
Only use concordant results in calculating the average titre.
20.94 mL + 21.01 mL +, 21.03 mL = *20.99 mL*
d. What is the difference between ***end point*** and ***equivalence point?***
Equivalence point is a point in the titration where the two reactants have been mixed in the conical flask in exactly the right stoichiometric ratio. The end point, however, is where the indicator changes colour to indicate that the reaction is complete and no more titrant should be added.
e. Perform the following calculations that relate to the titration. Show all working out.

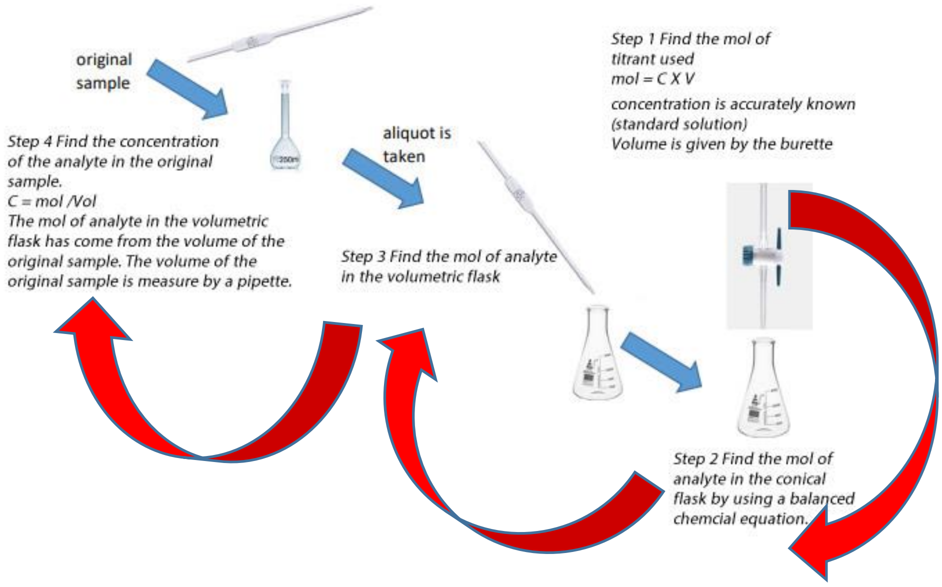
i. Calculate the amount, in mol, of chlorine, Cl_2, present in the average titre.
mol = C X V = 0.010 mol/L X 0.02099 L = 0.000299 mol = 2.99 X 10^{-4} mol

ii. Calculate the amount, in mol, of hydrogen sulfide, present in a 20.00 mL sample of diluted water from the volumetric flask.
According to the balanced chemical equation
$4Cl_2(aq) + H_2S + 4H_2O(aq) \rightarrow SO_4^{2-}(aq) + 10H^+(aq) + 8Cl^-(aq)$
For every 4 mol of Cl_2 1 mol of H_2S reacts.
=> mol of H_2S in the 20.00 mL sample of diluted water is ¼ X 2.99 X 10^{-4} mol
=> 7.48 X 10^{-5} mol

iii. Calculate the amount, in mol, of hydrogen sulfide, in the volumetric flask.
=> (200/20) X 7.48 X 10^{-5} mol = 7.48 X 10^{-4} mol

Iv Calculate the concentration, in mol/L, of hydrogen sulfide, in the contaminated water sample
Since all the mol of H_2S in the volumetric flask came from the 10.00mL the concentration of H_2S in the contaminated water s therefore
=> 7.48 X 10^{-4} mol / 0.0100 = 7.48 X 10^{-6} mol/L

Since this question required dilution of the original sample before titration, four steps are required as shown on the right.



step 1 - find the mol of titrant by using the concentration of the standard solution and the average titre.

Step 2 - find the mol of analyte by using the stoichiometric ratio from a balanced chemical equation

Step 3 – find the concentration of the analyte in the volumetric flask multiplying the mol of analyte in the conical flask(step 2) by the ratio (volume of volumetric flask/volume of aliquot delivered into the conical falsk)

Step 4 – find the concentration of analyte in the original sample using the mol of analyte in the volumetric flask (step 3) and the volume of sample diluted using the volumetric flask.