Titration

**Introduction**

This is one of the essential skills needed in chemistry, It involves using a burette to accurately measure the volume of one solution that is required to react completely with a known volume of a second solution (usually measured using a pipette). This then allows you to work out the concentration of the unknown solution.

Titrations are usually carried out to determine the exact concentration of a solution but the same technique can sometimes be used for the preparation of soluble salts.

The most common titrations are those involving acids and alkalis but you may also come across: redox titrations ( such as iodometric titrations), complexometric titrations (such as those used for determining calcium) and precipitation reactions.

**Safety measures**

If you are titrating with liquids that are corrosive, irritant, toxic etc, eye protection will be needed (though the solutions used are usually between 0.01–0.2 M and so of low hazard). To determine the level of protection, and any other precautions, consult the appropriate entry in the Hazardous Chemicals Database.

**Method**

1. Rinse the burette with the solution to be used. (This avoids any dilution of the solution about to be placed in the burette).
2. Fill the burette with the solution, using the method described earlier, Note the initial liquid level (burette reading).
3. Rinse and then fill the volumetric pipette with the other solution to be used. This avoids any dilution of the solution about to be placed in the pipette. See earlier section on pipettes.
4. Transfer the aliquot of one reagent from the pipette into a clean conical flask.
5. Add an indicator or other required reagents (eg, acid for some redox reactions) to the flask at this point.
6. Turn the tap so that the liquid in the burette starts to run into the flask. You can go fast at first.
7. Watch for a change of colour in the conical flask. Initially, you will probably see nothing. After a while though you will see the colour change around where the stream of titrant falls into the other reagent.
8. Slow down the stream from the burette and start swirling now. As you start to get nearer the end point, you will see that more and more swirling is needed to clear the colour change. It is best to stop now and start adding in small amounts at a time. 0.5 cm3 or so.
9. When it does not change back on swirling, stop and note the new burette reading to one decimal place. This is your ‘rough’ titration volume.

*In some cases the end point fades and you will probably have to add a little more until it either does not change back or takes longer than a specified time.*

1. Empty the flask and dispose of the contents of the flask as appropriate, depending on what is in it (Consult the SSERC Hazardous Chemicals Database for information on disposal). If you don’t have another clean flask ready, rinse your flask twice with tap water and then twice with distilled water. There is no need to dry it.
2. Refill the burette if required. If your rough reading is more than half the capacity of the burette, you will need to refill it – otherwise you will run out in the middle of your titration. Note the initial burette reading again.
3. Repeat the titration but this time quickly add the solution from the burette to within 1 cm3 of your ‘rough’ titration volume.
4. Now add the solution much more slowly, dropwise, from the burette, swirling the liquid in the conical flask until the required end point (eg, indicator colour) is reached.
5. Note the new burette reading and work out the volume delivered by the burette (the ‘titre’) to the nearest second decimal place.
6. Repeat the accurate titrations at least twice more (plus additional runs if time allows).

*The level of accuracy will vary depending on the nature of the reaction (and the level the student is working at!*

1. Calculate an average of the accurate titration volumes to obtain the volume of the solution in the burette required to just react with the volume of the solution in the conical flask.

**Notes**

With acid/alkali titrations it is better to place the acid in burette. The reason for this is that

(i) alkalis are normally solids after evaporation so it is possible that residues may block the jet

(ii) alkalis can also react with any grease on the burette barrel to form a solid. The solids can block the jet or cause ground glass taps to stick. This is less of a problem with modern burettes with PTFE taps.

Similarly if you have two reagents, one of which is a solution of a solid and the other is a liquid (or solution of a liquid – or even a gas) it is best for this latter one to be in the burette.

## Back Titrations

While this technique is given its own name, it is in practice exactly the same as a standard titration.

In many cases a standard titration reaction might be slow to go to completion or the titration endpoint may not be sharp or the Standard Solution is not stable. In these cases, a back titration may be useful. In a back titration, an excess of standard solution is added to the analyte solution. The analyte reacts with this standard solution and any excess standard is then titrated (back-titrated) with a second Standard Solution. If you know how much of the standard you added and the titration tells you how much is left, the difference is how much reacted.

an example might help.

Analysing the weak bases in antacids by reacting with standard acid solutions can be difficult. Many antacids do not readily dissolve in water or they react slowly with acids.

The procedure is:

1. an excess amount of Standard HCl is added to the sample
2. the mixture is heated to make sure the reaction is complete.
3. the mixture is then titrated against standard sodium hydroxide.