Titrations

The most common use of titrations is for determining the unknown concentration of a component (the analyte) in a solution by reacting it with a solution of another compound (the titrant).

In industry titrations are used for various reasons.

While there are many different types of titrations, acid-base titrations are the most common. Consider this example in which a sample of hydrochloric acid (HCl) is titrated with sodium hydroxide (NaOH).

$$HCl + NaOH \rightarrow NaCl + H_2O$$

During the course of the titration, the titrant (NaOH) is added slowly to the unknown solution. As it is added, the HCl is slowly reacted away.

The point at which exactly enough NaOH has been added to react with all of the HCl is called the equivalence point. Up to the equivalence point, the solution will be acidic because excess HCl remains in the flask. After the equivalence point, there will be an excess of NaOH and the solution will be basic.

An acid-base indicator can be used to help identify when the change from acidic to basic occurs.

Phenolphthalein is colourless in acidic solutions and bright purple in basic solutions. As such, it should change from colourless to purple around the equivalence point of this titration.
Our approximation of where the equivalence point occurs is called the endpoint. Care must be exercised when an indicator is chosen for a titration to ensure that the endpoint coincides as closely with the equivalence point as possible.

Performing the Titration

We will now look at the individual steps required to perform this kind of titration.

1. A known quantity of the unknown solution (HCl) is pipetted into a flask and several drops of indicator are added (see Image 1). If phenolphthalein is being used as an indicator, the solution should remain colourless at this point. The flask is placed on white paper or tile to make the endpoint easier to see.

Image 1

2. Make sure the buret stopcock is closed (Image 2) and then rinse the inside with several millilitres of NaOH. The buret should be held nearly horizontally and rotated so that the entire inside surfaces are contacted by the NaOH (Image 3). Some NaOH should also be run through the stopcock to clean it as well. Cleaning is normally performed over a sink.

Image 2 & 3

3. Make sure the stopcock is closed. Place the buret in a buret clamp (Image 4) and fill it carefully with NaOH. Use a beaker with a spout or funnel to reduce the possibility of spilling the NaOH. (Image 5).

Image 4

Image 5

4. Drain some titrant through the stopcock into a waste beaker. Make sure that no air bubbles remain in the stopcock. (Image 6).

Image 6

5. Read the volume of the buret, (Image 7). This is your initial volume (14.62 ml in this case). Reading is made easier by holding a piece of dark paper behind the buret.

Image 7

6. Place the flask containing the unknown under the buret. Slowly open the stopcock and add some NaOH (usually a milliliter or so). You may notice a temporary colour change in the solution near where the NaOH was added. (Image 8). Stir the solution thoroughly. Any colour change should disappear

Image 8

7. Continue adding NaOH in small quantities. As the titration progresses, the colour change described in step 6 will take longer to disappear. This signals that the endpoint is getting closer and that the NaOH should be added in smaller and smaller quantities. NaOH should be added drop wise very close to the endpoint.

8. The endpoint of the titration is signalled when a permanent colour change is observed (longer than 30 seconds). It is possible to overshoot the endpoint by adding too much NaOH. A correct endpoint is shown below on the left, (Image 9)an overshoot endpoint on the right, (Image 10).

Image 9 & 10

9. Record the volume in the buret, (Image 11). This is your final volume (26.48 ml in this case). Subtract the initial volume (step 5) from the final volume to determine the volume of titrant added (26.48 - 14.62 = 11.76 ml).

Image 11

10. Use standard chemical calculation methods to determine the concentration of HCl.