ACID-BASE TITRATIONS

METHOD:

Step 1: An accurately known volume (**aliquot)** of the solution whose concentration is to be determined, together with an appropriate indicator is placed into a **conical flask** using a **pipette**. This solution is referred to as the "unknown".

Step 2: The **standard solution** (a solution whose concentration is accurately known) is placed into a calibrated tube known as a **burette**. This solution is referred to as the "known".

Step 3: An accurately known volume of the standard solution **(titre)** is delivered until there is a permanent colour change in the conical flask.

This process is referred to as a **titration**.

The burette reading at the point at which stoichiometrically equivalent amounts of acid and base have reacted is referred to as the **equivalence point** (or **stoichiometric point**) of the reaction. At this point, neither reactant is present in excess.

The reading on the burette at the point at which the indicator permanently changes colour is known as the **end point** of the reaction.

Ideally, the equivalence point and the end point should coincide, but this does not always occur. Indicators must therefore be carefully chosen so that the end point matches the equivalence point as closely as possible.

Note:

- There are always errors associated with measurements made during experimental work. Typical uncertainties associated with volumetric analysis include:
  - $20\ ml$ pipette: $\pm 0.05\ ml$
  - Burette: $\pm 0.02\ ml$
  - $250.0\ ml$ volumetric flask: $\pm 0.3\ ml$
- Although burettes are calibrated in intervals of $0.1\ ml$, the volume can be estimated to the nearest $0.02\ ml$. Therefore **every** volume should be recorded to **2** decimal places.
- Volumes (titres) are read from the bottom of the meniscus and should be reported to 2 decimal places (error is $\pm 0.02\ ml$).

  For example: In the diagram on side, the titre is $14.58\ ml$.

- If the meniscus lies exactly on a line, it should be recorded to the second decimal place eg. $15.60\ ml$
- In some titrations, the "known" is placed into the conical flask and the "unknown" is placed into the burette (reverse order titration). Beware!!!

- To minimise errors, titrations should be repeated until three concordant titres are obtained i.e. three titres that differ by a maximum of $0.10\,ml$ (2 drops) from highest to lowest.

- In **most** titrations, the end point occurs **after** the equivalence point of the reaction. This is not, however, always the case.

  The order simply depends upon the strengths of the reacting species (and hence the pH at the equivalence point), and the pH across which the indicator changes colour.

QUESTION 1

Benzoic acid (C_6H_5COOH) is used as a preservative, particularly in soft drinks.

Phenolphthalein indicator was added to $20.0\,mL$ of $0.100\,M$ benzoic acid solution and the resulting solution was then titrated with $0.200\,M$ sodium hydroxide.

What volume of sodium hydroxide solution is required to neutralise the benzoic acid?

Solution

Write an equation to represent the reaction occurring:

$$C_6H_5COOH_{(aq)} + NaOH_{(aq)} \rightarrow C_6H_5COONa_{(aq)} + H_2O_{(l)}$$

Determine the amount, in mol, of the known species:

Known: C_6H_5COOH

$V = 0.020L$
$c = 0.1\,M \qquad n = cV = 0.002\,mol$

Use the amount of known as well as the mole ratios in the equation to determine the amount of unknown:

Unknown: $NaOH$

$$n(NaOH) = n(C_6H_5COOH) = 0.002\,mol$$

Calculate the required value:

$$V = \frac{n}{c} = \frac{0.002}{0.2} = 0.0100\,L = 10.0\,mL$$